Original Research

Industrial Noise Levels in Bangladesh; is Worker Health at Risk?

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Received: 24 November 2013
Accepted: 28 April 2014

Abstract

This study assessed the environmental noise of select industries in Chittagong city and tried to relate the findings with occupational health to evaluate the vulnerability of workers toward possible health injuries. Sound levels were measured based on industry types and zones within industries. Eight different industries of the Nasirabad area were selected, divided into three zones, and categorized as steel, garments, and aluminium industries. The mean maximum and minimum sound levels ranged between 77.26 to 96.53 and 67.71 to 86.62 dBA, respectively. Sound levels also varied significantly ($p < 0.05$) within the same and between the different zones. From median observation, 25th and 75th percentiles maximum and minimum sound levels again showed a significant ($p = 0.00$) variation for different types of industries. The overall analysis of this study could be regarded as arbitrary baseline data for further studies or concerned stakeholders in Chittagong city.

Keywords: industrial noise pollution, Chittagong, pollution, apparel industry noise, steel mill noise

Introduction

Bangladesh is a developing country located in Southeast Asia. Like other developing countries, it is slowly but steadily transforming from an agrarian economy into an industrial one, showing the classical signs of poor pollution management and negative environmental footprint. Among the aggravating environmental concerns within the expanding industrial scenario, noise is a very important one. Evidently, industrialization along with rapid urbanization and a developed transportation system play a significant role behind the increased noise levels globally [1]. The main sources of noise are the industries populating the industrial and non-industrial zones amidst the landscapes of all the cities and city suburbs of Bangladesh. Noise ranging from mild to severe emanating from industrial sources is affecting a large number of individuals, including industrial workforce and people living in the vicinity of these industries [2-4]. Alongside home and educational places, occupational environment is an unavoidable part of our living. Exposure to high occupational noise causes annoyance and higher rates of hearing loss. Besides, it is related to many other health problems among the workforce serving in industries like metal processing, textiles, garments, construction, shipyards, and mining [5-7]. Premature hearing loss, blood pressure alteration, hypertension, several cardiovascular and non-cardiovascular diseases, and lack of concentration among industrial workers are well-known outcomes of noise exposure at work [5, 7-10]. In order to ensure a healthy and a vibrant economy for Bangladesh, it is imperative to protect the population – especially the industrial workforce – from the hazardous work environments.

There is a stark lack of information regarding noise exposure at occupational environments in most of the non-

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industrialized countries. However, workers exposed to high occupational noise have been reported in 17 studies conducted in 12 countries in South America, Africa, and Asia [11]. Occupational hearing loss owing to prolonged exposure to noise continues to be the most prevalent among the 10 leading occupational diseases in both Canada and the United States [12]. There is mounting confirmation that noises above 80 dBA in the workplace are hazardous to health [13]. Besides, louder occupational noises can cause a reduction in behavioral efficacy and may lead to workers being predisposed to aggressive behavior [14]. Workers exposed to high noise levels have more social conflicts both at home and work, consequently decreasing confidence and leading to consistent deterioration in performance [11].

As is quite apparent from the past experience that the extremity of noise reduces the productivity of the working staff in the long run, it has become a challenge to control noise in industrial arenas. Several health safety precautions could be practiced in order to reduce the potential health hazards to workers. However, the reality is these protective measures are often not centered in a planned way and hence may add extra costs to industries [15, 16]. Numerous studies [5-7, 11, 17-19] on workplace noise exposure and its associated impact on workers have been done so far around the world. In Bangladesh, a few studies carried out by Haider et al. [20] and Sultana et al. [21] have assessed noise intensities in the workplace. But in Chittagong, no study has yet been conducted to assess the intensity of occupational noise in different industries. The present study is, therefore, an attempt to investigate the amplitude and intensity of machine- and equipment-induced noise at different industries in Chittagong, and also to relate the findings to the question of whether worker health is at stake.

Materials and Methods

A reconnaissance survey was carried out at the beginning to locate the study area in Chittagong, Bangladesh. Based on that, Nasirabad industrial area was selected for study because it had the intended industries altogether in comparison with other industrial areas of Chittagong. Eight industries of three different categories (steel, garment, and aluminium) were chosen for assessing the noise levels. The study area was divided into three zones.

- Zone-A (consisting of Baby Super Market area, Ruby Gate area and Textile Gate area): Islam Steel Mills Ltd. (ISML), BENZ Industries Ltd. (BIL), and Design Apparels Pvt. Ltd. (DAPL)
- Zone-B (consisting of Shershah area): Meghna Steel Industries Ltd. (MSIL) and Delli Aluminium Factories Ltd. (DAFL)
- Zone-C (Bayezid Area): K.S. Aluminium Industries Ltd. (KSAIL), Mars Apparels Ltd. (MAL), and Nazia Apparels Ltd. (NAL)

The locations of the studied industries are shown in Fig. 1. Data were collected three days a week during July to September, 2010. Maximum and minimum sound levels were recorded at three different spots (entrance, premise, and inside) in each of the industries during three different time periods of the day (9.00-11.30 am, 12.00-1.30 pm, and 3.00-4.30 pm) using a multifunctional digital sound level meter (SL-5868P). Measurements were taken more than 1 m away from the source, and for all the measurements the sound level meter was held above 1.5 m from the ground level and 1 m away from the chest. 'A' weighting mode was used for measuring the sound levels. The linear distance of each spot in respect to the sound sources, from inside of the factories toward the entrance was also measured. All the measurements were replicated twice to get an average value of the maximum and minimum sound levels (dBA). The vicinity of the installed machineries and the interior of the workplace or production unit were considered as sources of noise. In each industry, sound levels were recorded at the gate after entrance, the maintenance section with generators and exhaust fans mostly, and the workplace, where machinery varied based on industry type.

Data were analyzed statistically using Predictive Analytics Software (PASW) 18 and STATISTICA 8.

Results

Fig. 2 (a-c) shows spatial dynamics of mean maximum and minimum sound levels of the studied industries. Trends for mean maximum and minimum sound levels with distance were similar and severally observed immediate to the sound source and the values showed a marked declining trend as the distance gradually upsurged in all sites (Fig. 2a). These patterns seem to be extremely reliant on noise source geometry, like locational setting of the studied industries; meteorological parameters such as temperature, atmospheric turbulence, and wind during the sampling period; atmospheric absorption, ground absorption, and reflections; and obstructions at all the studied industries [22, 23].

The mean maximum and minimum sound levels also showed a marked industry (steel, garments, and aluminium manufacturing) variation (Fig. 2b) whereas the spatial variation of sound levels showed similar patterns in most of the study sites (Fig. 2c). Both the maximum and minimum sound levels stretched the maximum value in inside for almost all the studied industries and continued to ease toward the entrance. This indicates a strong variation of noise due to running machines and other equipment in the studied industries, stated by Haider et al. [20] and Sultana et al. [21], who assessed the occupational noise levels in the textile and fertilizer industries in Bangladesh, respectively, while Tak et al. [24] worked on similar aspects in some other parts of the world. Inside the metal (steel, aluminium) and textile industries, running heavy machinery and equipment for product fabrication, product assembly, power generation, and processing create heavy noise. This is accompanied with the loading, unloading, and other supporting metals and textile processing activities generating noise on the premises [20] which might be cause for increased maximum and minimum sound levels in the inside and on premises for all the industries during the present study.

Mean maximum and minimum sound levels from three different zones of the studied industries are presented in Table 1. The mean maximum sound levels ranged between 77.26 and 96.53 dBA, while the mean minimum sound levels were in the range between 67.71 and 86.62 dBA. Of all the industries, aluminium industries (specifically K.S. Aluminium Industries Ltd; mean max. 96.53 and mean min. 85.13 dBA; followed by Delli Aluminium Factories Ltd., mean max. 90.98 and mean min. 86.62 dBA) of Zone B were under the most strident state in terms of occupational environment for noise and the noise there was higher ($P < 0.05$) than that of all other industries included in the study.

Maximum and minimum sound levels at three different locations within the industry for three different zones during three time periods in a day are shown in Table 2. For zone-A, sound level was the maximum during 3.00-4.30 pm at inside, premise, and entrance. But for zone-B, at inside, the maximum sound level was observed during 12.00-1.30 pm, at premise and entrance, these zonal industries followed the same temporal variation pattern of zone-A industries. For zone-C, an absolutely unlike temporal variation pattern was observed. At the inside and premise, the maximum sound level was observed during 9.00-11.30 am while for the entrance it was during 3.00-4.30 pm. For the entire three zones, minimum sound levels of industries also showed similar patterns like maximum sound levels and varied significantly ($p < 0.05$) within the same and between the different zones during different periods at different locations.

Fig. 3 shows the distribution (median, 25th and 75th percentiles, non-outliers range, outliers, and extremes) as well as the heterogeneity of the maximum and minimum sound levels of the studied industries. When the steel industries (ISML, BIL, and MSIL) are considered, the upper 50% of the maximum sound level values lie in between 80-86 dBA while for minimum sound levels the range is 71-75 dBA in comparison with the much higher range of noise (90-92 dBA) recorded by Kerketta et al. [19] in the steel mills of India. MSIL had much longer bottom whiskers for maximum and minimum sound levels, indicating much lower values in comparison with other steel industries. For garment industries, the upper 50% of the data set of DAPL had maximum and minimum sound level values over 86 and 77

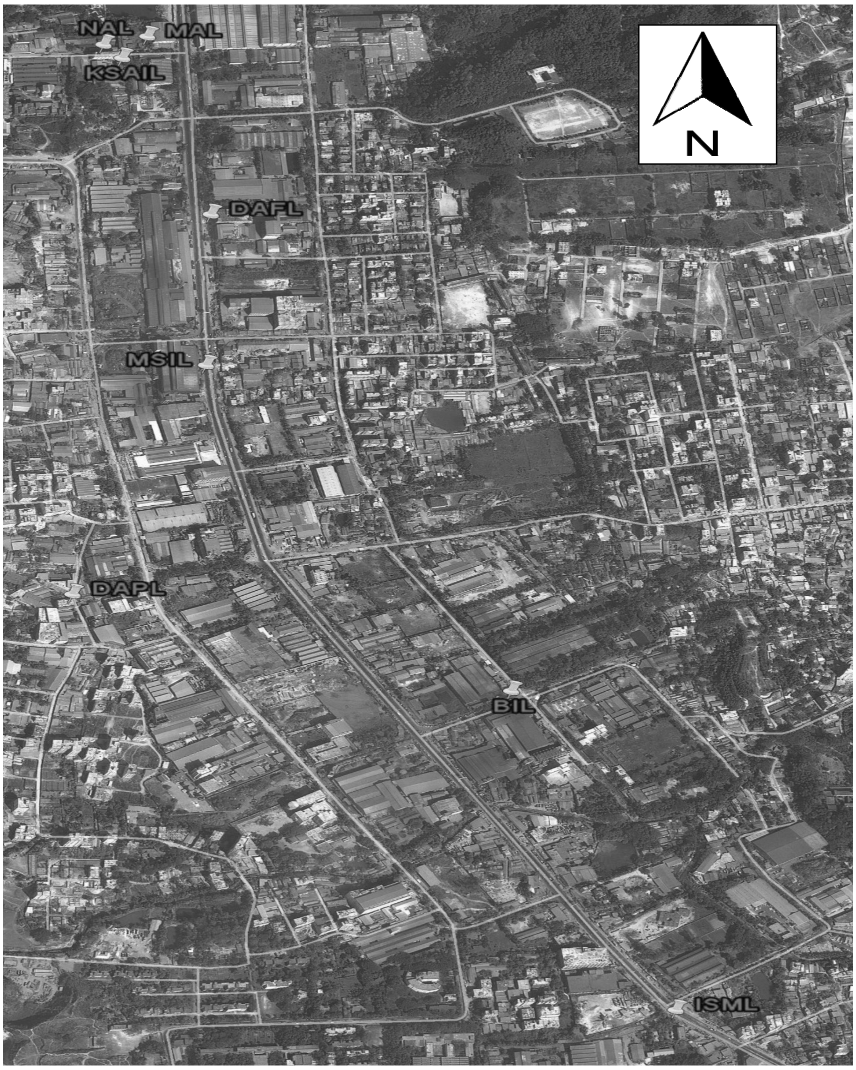

Fig. 1. A map of Nasirabad industrial area of Chittagong, showing the locations of the studied industries.

dBA, respectively, in comparison with the MAL and NAL. Longer bottom whiskers of minimum sound levels for NAL indicate lower minimum sound levels there, while longer upper whiskers exhibit higher maximum sound levels in DAPL.

In the case of aluminium industries, maximum and minimum sound levels showed much higher value in comparison with other industry categories. Upper 50% of the data set of KSAIL had maximum and minimum sound level values over 95 and 84 dBA, respectively. In the aluminium industry category, though KSAIL had much higher maximum sound level values for 50% data set, DAFL had much higher minimum sound level values for 50% data set. Furthermore, both the maximum and minimum sound levels of the studied industries varied significantly (p=0.00) when median, 25th, and 75th percentiles of the data set were considered.

Discussion

Around the world, a significant proportion (16%) of hearing impairment results from strenuous exposure to occupational noise [11]. Considering this, the present study assessed noise pollution levels in three zones of the Nasirabad industrial area in Chittagong, consisting of the steel, aluminium, and garment industries. Undesirably, as the study discloses, recorded maximum and minimum noise levels at entrance, premises, and inside during the day in all the industries under different study zones exceeded the standard noise level for industrial zones in some countries (Table 3).

In the present study, the maximum and minimum noise levels ranged from 96.53-78.53, 84.96-68.57, and 90.48-72.48 dBA, respectively, at KSAIL (aluminium), MSIL (steel), and DAPL (garments), representing the worst industries of three categories. Sultana et al. [21] reported significantly high levels of noise (>90 dBA) in the inside and premises of Ashuganj Fertilizer Company Ltd. Ashuganj, Bangladesh, and Haider et al. [20] reported noise levels in the range of 86-88, 90-95, and 96-100 dBA in different parts of textile industries in Kashim Bazar, Gazipur, Bangladesh. Although the values obtained in the present study varied with those observed by Sultana et al. [21] and Haider et al. [20], the unpleasant truth is that noise levels were well above the acceptable noise limit approved by the Department of the Environment (DoE), Bangladesh (75 dBA), WHO (65 dBA), and the U.S. EPA (70 dBA) for industrial areas during daytime [25, 26]. Chauhan et al. [26] reported noise in the range of 88.56-109.16 dBA and in some cases 89.56-120 dBA for the industrial zone in Moradabad City of Uttar Pradesh, India. They also reported much higher maximum (94.6 dBA) and minimum (82.6 dBA) sound levels in the industrial zone of Dehradun, Uttarakhand, India. The findings of the current study are also in conformity with the findings of some other studies

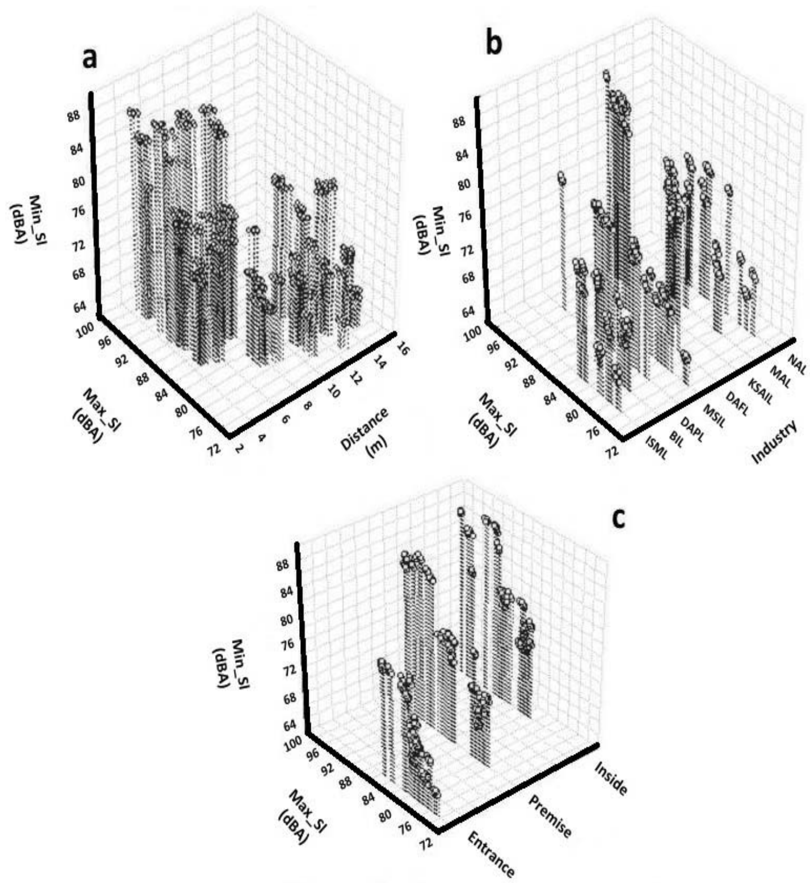

Fig. 2. Variation of mean maximum and minimum sound levels (dBA): (a) with distance (m), (b) in different industries and, (c) with sampling location.

Table 1. Mean maximum and minimum sound levels (dBA) at different industries with their linear distances from the source.

Zones	Industries	Location	Linear distance from the source (m)	Sound level (dBA)	
				Maximum	Minimum
Zone A	Islam Steel Mills Ltd. (ISML)	Entrance	14.7	77 a	68 a
		Premise	8.7	80 b	69 b
		Inside	5.7	84 d	75 e
	BENZ Industries Ltd. (BIL)	Entrance	14.7	79 a	69 b
		Premise	7.7	80 b	71 c
		Inside	4.8	84 d,e,f	72 d
	Design Apparels Pvt. Ltd. (DAPL)	Entrance	11.8	80 b,c	76 e
		Premise	7.8	86 g	78 f
		Inside	4.8	90 i	79 f
Zone B	Meghna Steel Industries Ltd. (MSIL)	Entrance	12.8	77 a	69 b
		Premise	7.7	81 c	71 c
		Inside	4.8	85 e,f	73 d
	Delli Aluminium Factories Ltd. (DAFL)	Entrance	13.7	81 c	78 f
		Premise	8.6	91 i	85 g
		Inside	4.6	91 i	87 g
Zone C	K.S. Aluminium Industries Ltd. (KSAIL)	Entrance	11.7	85 f	79 f
		Premise	7.7	95 j	85 g
		Inside	4.7	97 k	85 g
	Mars Apparels Ltd. (MAL)	Entrance	10.7	80 b	71 c
		Premise	6.7	86 g	77 e
		Inside	4.8	89 h	78 f
	Nazia Apparels Ltd. (NAL)	Entrance	10.8	77 a	69 b
		Premise	7.7	84 d,e	76 e
		Inside	4.7	87 h	78 f

Figures followed by the same letter (s) in the same column do not vary significantly at $p < 0.05$, according to Duncan's multiple range test (DMRT).

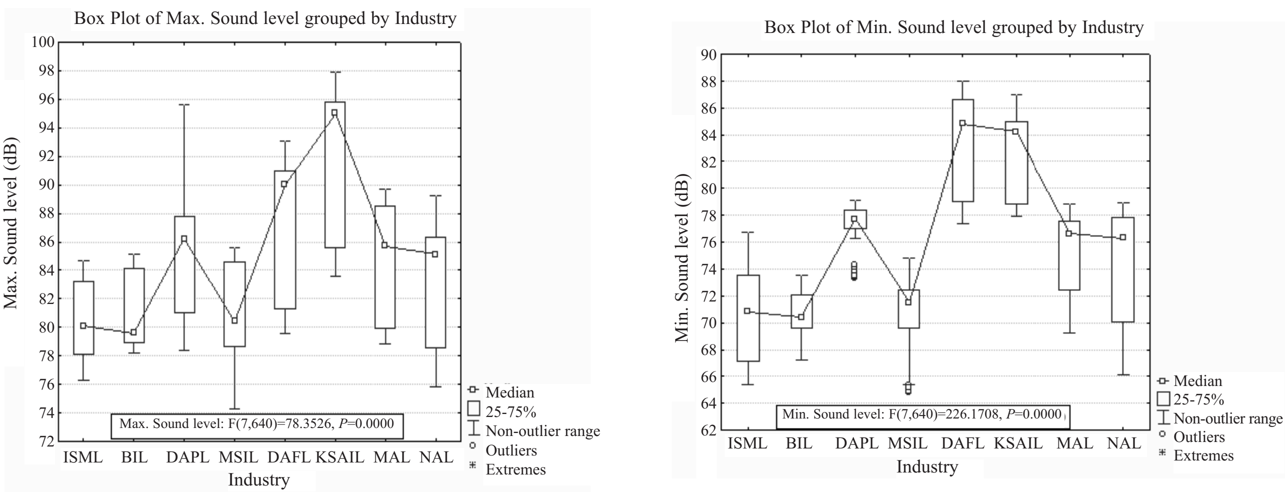

Fig. 3. Distribution (median, 25[th] and 75[th] percentiles, non-outliers range, outliers, and extremes) of maximum and minimum sound levels (dBA) at different industries.

Table 2. Mean maximum and minimum sound levels (dBA) of studied industries at different locations and times of day.

Location	Time period	Sound level (dBA)					
		Zone A		Zone B		Zone C	
		Max.	Min.	Max.	Min.	Max.	Min.
Entrance	9.00-11.30 am	78 a	70 a	77 a	72 a	80 a	74 a
	12.00-1.30 pm	79 a	70 a	80 a	74 a	81 a	72 a
	3.00-4.30 pm	79 a	73 b	80 a	74 a	81 a	73 a
Premise	9.00-11.30 am	82 b	73 b	85 b	78 b	90 b	80 b
	12.00-1.30 pm	82 b	72 b	86 b	78 b	88 b	79 b
	3.00-4.30 pm	82 b	72 b	86 b	78 b	87 b	79 b
Inside	9.00-11.30 am	88 c	75 c	89 b	80 b	92 b	81 b
	12.00-1.30 pm	85 c	75 c	88 b	80 b	91 b	80 b
	3.00-4.30 pm	85 c	76 c	87 b	80 b	90 b	80 b

Figures followed by the same letter (s) in the same column do not vary significantly at $p < 0.05$, according to Duncan's multiple range test (DMRT).

Table 3. Noise level standards for industrial areas of some select countries.

Country	Noise level for industrial zone (dBA) Day/Night
Bangladesh (DoE)	75/70
Australia	65/55
India	75/70
Japan	60/50
U.S. (E.P.A.)	70/60
W.H.O. and E.C.	65

Source: Farooque and Hasan [25]; Chauhan et al. [26].

[5, 24, 27] around the world where varied high noise levels were reported in different metal and garment industries.

The impact of occupational noise is not uniformly distributed among all workers. During an onsite visit in steel industries it was observed that steel industries consist of five sections: steel melting, rolling mill, quality control, maintenance, and administration. Workers in the first three departments were continuously exposed and in last two were intermittently exposed to noise. The aluminium and garments industries also had more or less similar sections where workers deal with running machinery and equipment inside the industry and were continuously exposed to noise, whereas workers of the maintenance and administrative sections were intermittently exposed to noise. Again, males usually experience greater exposure to noise at work than females due to differences in occupational categories, economic sectors of employment, and working lifetime. Nelson et al. [11] reported that a heavier burden is borne by male workers and 2.8 million DALYs (disability-adjusted life years) in comparison with female workers at 1.4 million DALYs.

Narlawar et al. [18] observed that a significant positive association between duration of exposure and prevalence of hypertension also reported a proportional association of occurrence of hearing impairment and duration of exposure among workers of metal industries. That study reported that hypertension prevailing among the continuously exposed workers (25.51%) was significantly higher than the intermittently exposed workers (14.05%), and the prevalence of hearing impairment was more significant in the first category of workers (20.5%) than the second category (8.91%).

Ali [14] reported 47% of the industrial workers in Egypt contending that workplace noise disturbs their peace of mind and 31% of them thought the high work place noise makes them angry or upset with distressing family behavior at home. Continuous exposure to noise may also result in lack of confidence in speech communication, leading to social isolation and difficulties in communication both at home and work, and disrupts the lives of those directly impacted as well as their families, friends, and co-workers [11]. Among the physiological consequences of continuous exposure to noise are hearing impairment, hypertension and blood pressure alteration. Eleftheriou [7] studied the effects of industrial noise on hearing loss of workers in Cyprus over the period of 1996 to 1999 and reported 27.8% suffered hearing damage while 7.7% suffered serious hearing loss. A number of studies observed a strong positive correlation between high noise exposure, the hearing impairment, blood pressure alteration, and hypertension [6, 18, 24].

In another study, Chang et al. [6] reported that young females are more susceptible to occupational or environmental noise exposure causing elevated systolic and diastolic blood pressure (SBP and DBP) on adults. That study showed that an increase of 5 dBA in noise exposure significantly causes transient elevations of 1.15 mm Hg SBP and 1.16 mm Hg DBP in daytime and 0.74 mm Hg SBP and 0.77 mm Hg DBP at night, respectively, in all the subjects. Ahmed et al., [12] reported that 38% of exposed industrial workers in a steel and air conditioning unit manufacturing plant in Saudi Arabia had hearing impairment 8-fold higher than non-exposed workers and for hearing impairment, high noise exposure in the workplace is the primary and age is the secondary interpreter.

Conclusions

- Results of this study showed that the mean maximum sound levels ranged between 77.26 and 96.53 dBA while mean minimum sound levels were in the range between 67.71 and 86.62 dBA in different industries of Nasirabad Industrial Area, Chittagong, Bangladesh.
- Aluminium industries are the most noise-generating industries as revealed by the present study. KSAIL (mean max. 96.53 and mean min. 85.13 dBA) followed by DAFL (mean max. 90.98 and mean min. 86.62 dBA) of Zone-B were under the most strident state in terms of occupational environment for noise in this study. More than 50% of the recorded data set of aluminium industries had maximum and minimum sound levels over 95 and 84 dBA, respectively.
- A significant temporal variation of noise levels was observed. For zone-A, noise levels reached the maximum value during 3.00-4.30 pm at the inside, premise, and entrance. But for zone-B, the maximum sound level on the inside was observed during 12.00-1.30 pm.
- Suitable countermeasures such as
  (a) Decreasing noise from sources
  (b) Using barriers
  (c) Using personal protective devices
  (d) Maximum daily exposure duration for industrial workers must be executed to protect the health of workers in Bangladesh and should be carried out by relevant ministries.
- For ensuring the well-being of industrial workers, the Bangladeshi government should take necessary steps for strict enforcement and monitoring of the Bangladesh Labor Act of 2006.

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