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Original research

The impact of loud noise on workers in granite factories in Aswan Governorate, Egypt

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Abstract:

Occupational noise exposure is a physical hazard that can lead to occupational diseases, including noise-induced hearing loss (NIHL), which is the most common occupational disease among industrial workers, particularly in granite processing industries. This paper aims to study the hearing health effects of workers exposed to excessive noise in granite processing industries. The noise levels were measured at primary operations by the selected granite factories in the study area, (the Aswan Industrial Zone), while a total of 104 workers were interviewed using a structured questionnaire that included sociodemographic data, working conditions, and the hearing symptoms they experience during and after work hours. The results showed that that the noise levels surpassed the limits established by Egyptian Environmental Law (90 dB). 40% of workers reported hearing symptoms consistent with the phenomenon of temporary transient hearing loss, such as tinnitus and temporary hearing loss after work hours. Statistically significant differences were recorded between noise exposure levels (by factory) and the incidence of hearing symptoms, with Factory A recording the highest number of TTS cases.

Keywords: noise, hearing loss, granite, temporary hearing loss

1- Introduction

Industrial noise is one of the most significant physical hazards facing workers in industrial environments, particularly in granite factories, which rely primarily on the operation of heavy equipment and machinery such as power saws, grinding machines, and cutting and polishing machines. These operations emit high levels of noise that may exceed environmental and health-related permissible limits, posing a direct threat to workers' health, particularly with regard to auditory function and the nervous system.

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According to the World Health Organization **(WHO, 1999)**, noise can be defined as unwanted sound that disrupts normal activities such as sleep and conversation, or impairs an individual's quality of life. The average noise level over a specified period is referred to as the time-weighted average (TWA), which is typically measured using the equivalent sound level, expressed in decibels (dB). Occupational noise is also defined as unwanted sound to which a worker is exposed in the work environment to an extent that may cause hearing damage or affect their physical and psychological health **(Bridger, 2003)**.

Studies indicate that noise levels in granite factories often range from 90 to 110 (dB) that exceed the maximum recommended by the World Health Organization (WHO), the U.S. Occupational Safety and Health Administration (OSHA), and the National Institute for Occupational Safety and Health (NIOSH), which is 85 dB for an eight-hour workday **(WHO, 1997; OSHA, 1983; NIOSH, 1998),** and the **Egyptian Environmental Law** which is 90 dB for an eight-hour workday. Continued exposure to such noise intensity can lead to noise-induced hearing loss (NIHL), which is an irreversible but preventable disorder that is the second most common form of acquired hearing loss, after presbycusis. It is defined as a progressive decline in hearing acuity resulting from sustained exposure to high sound pressure levels, causing damage to the inner and outer hair cells of the organ of Corti. It is characterized by irreversible, often bilateral and symmetrical sensorineural loss **(Jain et al, 2017)**. Also, NIHL is receiving increasing attention because, unlike many other occupational injuries, it is a permanent and, in most cases, irreversible condition. Chronic exposure to loud noise is a direct cause of elevated hearing thresholds, as detected using specialized audiometry. **(Clark & Bohne, 1999).**

Excessive noise is one of the environmental factors that have multiple negative effects on human health. Its damage is not limited to the auditory system only, as noise can appear in the form of physiological or psychological damage such as high blood pressure, sleep difficulties, nervous discomfort, psychological disorders and stress, in addition to what is known as Temporary Threshold Shift (TTS). **(Seidman & Standring, 2010).**

Occupational hearing loss is defined as a change in hearing threshold of 10 dB or more at frequencies of 2000, 3000, and 4000 Hz in one or both ears (NIOSH, 1998). Noise-induced hearing loss takes two main forms. Temporary threshold shift (TTS) is a temporary decrease in hearing ability, which often returns to normal after a period of rest from the noise. Permanent threshold shift (PTS) is an irreversible decrease in hearing ability, typically occurring after repeated, chronic exposure to high-intensity sounds, such as those experienced in industrial work environments or at loud concerts. **(Rabinowitz, 2000)**. It's worth noting that occupational noise is still associated with most industrial activities, but some industries including the granite industry are among the most exposed to high levels of noise, which increases the risk of NIHL among their workers.

Despite the existence of clear international legislation and standards regulating permissible noise levels in workplaces, the implementation of these regulations in granite factories, especially in developing countries, faces significant challenges. The most prominent of these challenges are weak monitoring and inspection systems, low awareness among workers and employers of noise hazards, and the absence of regular hearing screening programs. These shortcomings increase the likelihood of ongoing exposure to harmful noise levels, highlighting the importance of noise risk assessment and implementing effective hearing protection programs as a top priority in the occupational health and safety system.

Amedofu, (2002) conducted a study to assess the impact of hazardous noise on workers at a surface gold mining company in Ghana. The study included noise level measurements, medical history collection, otoscopy, and pure-tone hearing tests in five key areas. The results showed that all of these areas, with the exception of the workshop area, exceeded the permissible limit of 85 dB. Among 252 workers at the company, 59 (23%) were found to suffer from noise-induced hearing loss (NIHL) at 4 kHz, the most common frequency for this type of hearing loss. The study also demonstrated a direct relationship between the severity of hearing loss and both age and duration of noise exposure. Remarkably, 41 of the 81 workers (51%) had a history of noise exposure prior to joining the company and suffered from noise-related hearing loss. The results also revealed that the incidence and severity of hearing loss varied across the work location within the facility, with 14 workers (6% of the sample) experiencing hearing loss exceeding 25 decibels in speech frequencies. These findings suggest that environmental and historical factors preceding the period of employment within the company may contribute to the impact on workers' hearing health, calling for comprehensive prevention strategies that include pre-employment assessment and ongoing follow-up.

Gupta et al. (2012) conducted a study to evaluate environmental noise and operator noise dose generated by jackhammer drilling in seven granite quarries located in South India. Ambient noise levels were measured at varying distances and directions from the drilling source. The highest noise levels were consistently observed in the downwind direction, indicating the influence of wind on noise propagation. Importantly, the results indicated that operator noise dose levels exceeded permissible limits in all studied quarries.

Huang et al. (2018) studied the exposure to noise and its health effects among stoneworkers in Taiwan. The research involved monitoring both environmental and personal noise exposure, analyzing the frequency spectra of noise emitted from various machines across nine stone factories, and conducting pure tone audiometry tests on 55 stoneworkers compared to 25 administrative staff who served as controls. The results showed that the mean of 8-hour time-weighted averages for environmental and personal noise exposure were 85.0 ± 6.2 dB(A) and 87.0 ± 5.5 dB(A), respectively. In seven out of nine cases, personal exposure levels exceeded the corresponding environmental measurements. These findings suggest that occupational noise in stone working environments is a significant concern. The study concluded that stoneworkers exhibit early signs of NIHL, and the high-frequency peaks in noise exposure are particularly harmful to auditory health. The authors emphasize the need for strict adherence to occupational safety regulations by both employers and workers to prevent further hearing damage.

This study aims to measure the noise levels at different primary operations zone of the selected granite factories in the study area (Aswan Industrial Zone), and study the hearing health effects of workers exposed to excessive noise.

2. Material and Methods

2.1. Study area

This study was conducted in the industrial zone south of Aswan city on three granite factories (Factory A, B & C) with coordinates as in Table 1, Figure 1:

2.2. Climate of Study area

Aswan, like the rest of Egypt, experiences a hot desert climate. It has some of the hottest summer days of any city in the country and is among the hottest, sunniest, and driest cities

worldwide. During the summer months (June through September), average high temperatures consistently exceed 40°C (104°F), while nighttime lows stay above 25°C (77°F). Even in the coldest month, average highs remain above 23°C (73.4°F), and lows rarely drop below 8°C (46.4°F). Summers are exceptionally long and intensely hot, characterized by dry desert heat and abundant sunshine. Winters are short and comfortably mild, with occasional cool nights.

Table 1. Coordinates of the location of granite factories in the industrial zone in Aswan Governorate.

Location coordinates	E	N
Factory A	24.05080	32.93446
Factory B	24.05046	32.93523
Factory C	24.04592	32.93583

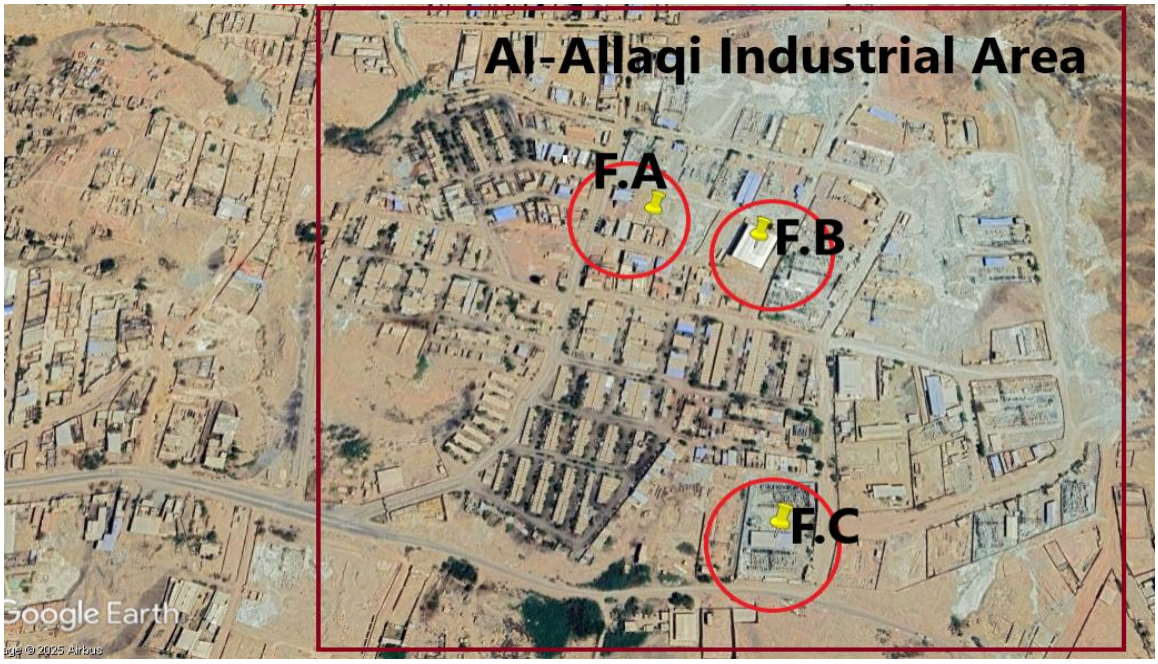

Figure 1. Location of granite factories in the industrial zone in Aswan Governorate.

2.3. Instrument

TENMARS MODEL: TM-101 (Figure 2) for measure noise intensity of the manufacturing units.

Figure 2. TENMARS MODEL: TM-101 device.

2.4. Measurement of Noise intensity

The noise levels of the three main units in granite factories, namely the cutting unit, the polishing unit, and the small cutting unit, were measured using the noise device TENMARS MODEL.
Study coverage included all production workers in the granite industry from the three selected factories (A, B, and C).

2.4.1. Sample size:

the study population consisted of a total of 104 male granite workers from the three factories.

3. Results and Discussion

3.1. Noise Levels (dB) at Different Sites Factories

Noise measurements were monitored for the main operations of the three granite factories, which are cutting units (saws), polishing, and small cutting unit.

Table 2. Mean Noise Levels (dB) at different sites Factory (A)

Sites	Noise Level (dB) actual data	The permissible exposure limits during 8 h Per Day (standard limits)		
		Egyptian Law	OSHA	NIOSH
Factory Yard	90	90	85	85
Cutting units (saw)	102	90	85	85
Polishing unit	95	90	85	85
small cutting unit	97	90	85	85

Table 3. Mean Noise Levels (dB) at different sites Factor (B).

Sites	Noise Level (dB) actual data	The permissible exposure limits during 8 h Per Day (standard limits)		
		Egyptian Law	OSHA	NIOSH
Factory Yard	89	90	85	85
Cutting units (saw)	103	90	85	85
Polishing unit	95	90	85	85
small cutting unit	98	90	85	85

Table 4. Mean Noise Levels (dB) at different sites Factory (C)

Sites	Noise Level (dB) actual data	The permissible exposure limits during 8 h Per Day (standard limits)		
		Egyptian Law	OSHA	NIOSH
Factory Yard	89	90	85	85
Cutting units (saw)	105	90	85	85
Polishing unit	90	90	85	85
small cutting unit	95	90	85	85

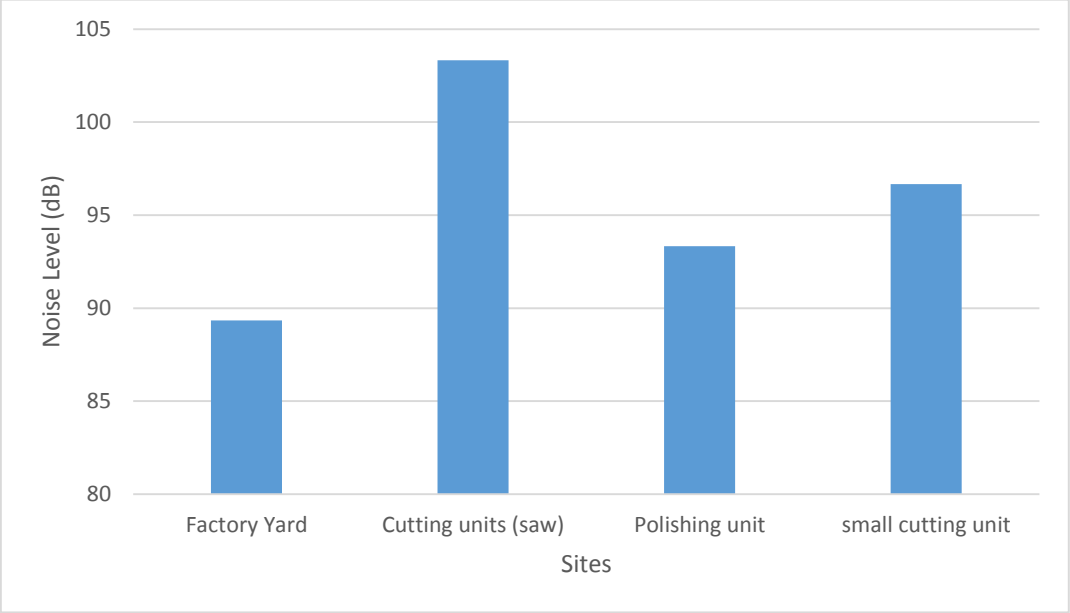

Figure 3. Average Noise levels in different sites

- Readings were taken while the machines were operating at peak hours

Measuring noise levels in granite factory work environments (Tables 3-5 & figure 3) showed that the noise levels surpassed the limits established by Egyptian Environmental Law (90 dB), the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety, and Health (NIOSH) (85 dB).

The Egyptian Environmental Law states that the maximum permissible level of equivalent noise intensity in workplaces with shifts of up to 8 hours is 90 decibels. The exposure period must be reduced if the equivalent noise intensity level exceeds 90 dB. By actually monitoring noise levels in granite factories, we find that noise levels range between 95 and 105 dB, which requires the worker to work for some time between one and four working hours as a maximum exposure.

3.2. Workers Health Effect:

A cross-sectional study was conducted to analyze the impact of occupational noise exposure on the hearing health of 104 workers distributed across three granite production plants. Data were collected through a standardized health questionnaire, including symptoms associated with noise exposure, as well as demographic and behavioral information. The results were then analyzed using SPSS version 23.0.

The results showed that 40% of workers (approximately 42 workers) reported hearing symptoms consistent with Temporary Threshold Shift (TTS), such as tinnitus and temporary hearing loss after work hours. Statistically significant differences were recorded between noise exposure levels (by factory) and the occurrence of hearing symptoms, with factory A having the highest number of TTS cases.

A relationship was also observed between years of experience and an increased likelihood of experiencing TTS, supporting the hypothesis of the cumulative effect of industrial noise on the hearing system. Analysis of variance (ANOVA) and logistic regression tests were used to determine the association of various factors, such as exposure duration, use of personal protective equipment, and field-recorded noise levels, with the occurrence of TTS.

Below is a statistical table showing the results of a study on the impact of noise on 104 workers in three granite factories, using a health questionnaire and analysis using SPSS version 23.

Table 5. Number of workers affected by noise in the three granite factories

Factory	Total number of workers	Number of workers who have a Temporary Threshold Shift (TTS)	Percentage of those affected (%)
Factory A	40	16	40.0%
Factory B	30	12	40.0%
Factory C	34	12	35.3%
Total	**104**	**40**	**38.46%**

Analytical Notes:

• The number of workers affected by noise and experiencing a temporary threshold shift (TTS) was approximately 40, representing 38.46% of the total study participants.

• The highest rate of impact was observed in Factory A, B at 40%, which may indicate weaker hearing protection measures in this factories.

• These results indicate the need to implement periodic prevention programs that include hearing screenings and worker training on noise hazard prevention.

Statistical Results:

• Chi-square = 0.214

• Degrees of freedom (df) = 2

• P-value = 0.898

Since the P-value is > 0.05, we find no statistically significant difference between the three factories in terms of the percentage of workers affected by Temporary Threshold Shift (TTS). This means that noise exposure and its effects on workers are similar across the three factories, according to these data.

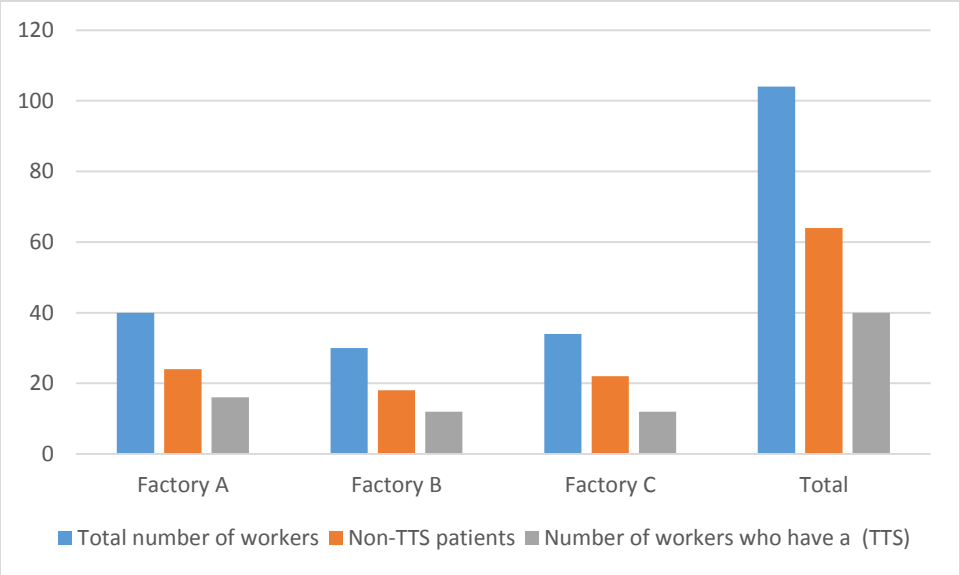

Figure 4: Distribution of the number of workers affected by the temporary threshold shift (TTS) and those not affected in three granite factories (A, B, and C).

These results indicate that occupational noise in granite factories poses a real health risk to workers, necessitating urgent intervention by implementing effective hearing protection strategies, including periodic hearing screening programs, training workers on the use of ear protectors, and modifying the work environment to reduce noise levels.

Kitcher et al, (2012) studied the noise-induced hearing loss (NIHL) on stone crushing industry workers from Ghana and gauging their awareness of how noise can impact health. It

involved a cohort of 140 dedicated stone workers juxtaposed against a control group of 150 health professionals.

Lindawati & Fitriadi (2018) conducted a study to analyze the noise levels generated by marble cutting machines in a Marble Production Unit located near the Polytechnic of South Aceh. To assess the noise exposure, the researchers measured both the Background Noise Level (BNL) and the Sound Pressure Level (SPL) using a Sound Level Meter Type SL 814. The average background noise level recorded was 53.03 dB. When the marble cutting machine was operated without a work piece, the highest recorded SPL was 94 dB. This level increased slightly to 96 dB when the machine was operated with a work piece. These measured values significantly exceed the recommended threshold noise level of 55 dB for educational environments.

Gyamfi et al, (2016) conducted a study to assess the extent of noise exposure and its impact on hearing capabilities among quarry workers in the Ashanti Region. This cross-sectional study involved 400 workers who were randomly selected from five quarries The results showed that all machines used in the quarries generated noise levels exceeding the minimum safety threshold, ranging from 85.5 dBA to 102.7 dBA. The study provides strong empirical evidence of the damage caused by excessive occupational noise exposure among quarry workers. These findings support the implementation of effective protective measures to reduce this occupational health risk.

Duran et al, (2020) studied occupational noise measurements taken at seven natural stone processing plants operating in Sivas, Turkey, and its surrounding areas. The data were evaluated using the task-based assessment method outlined in the TS EN ISO 9612:2009 standard. The highest noise levels to which workers were exposed were recorded near S/T block cutting machines, bridge cutting machines, sizing/honing machines, and head/side cutting machines, while the lowest noise levels were observed near narrow polishing machines and gang saw machines. To mitigate these risks, it was recommended that high-noise-emitting machines be isolated in separate compartments.

Reddy et al, (2017) studied quarry activities that have detrimental effects on both human health and the environment. The study measured noise levels at various locations within quarry sites and analyzed the distribution of quarry workers in relation to occupational health hazards caused by noise pollution. These locations included the quarry site, crushing area, drilling area, blasting area, transportation area, roadside, and nearby villages, with noise levels varying accordingly. The study revealed that quarry workers were significantly affected ($p < 0.0001$) within the specified study area due to their occupational exposure. It was found that 88% of quarry workers suffered from respiratory problems due to their work environment 68% with moderate symptoms and 20% with severe symptoms while only 12% remained unaffected.

4.Conclusion & Recommendation

The findings of this study clearly demonstrate that occupational noise exposure in granite factories has a measurable impact on workers' auditory health. Among the 104 workers surveyed across three granite factories, approximately 40% exhibited signs of Temporary Threshold Shift (TTS), indicating early auditory damage due to prolonged exposure to high noise levels.
Factory A recorded the highest percentage of affected workers (45%), followed by Factory B (40%) and Factory C (35.3%). These results underscore the urgent need for effective hearing

conservation programs, especially in industries like granite processing where noise levels exceed recommended limits.

Despite the availability of international standards for noise control and hearing protection, implementation remains insufficient, particularly in developing countries. Factors such as inadequate regulatory enforcement, lack of routine audiometric screening, and poor worker awareness contribute to the continued rise of noise-induced hearing loss (NIHL).

Recommendation

- Enforce stricter occupational noise regulations in granite industries.
- Conduct regular hearing assessments for all workers.
- Promote the use of personal protective equipment (PPE) like earplugs and earmuffs.
- Implement noise control engineering measures to reduce exposure at the source.

Proactive intervention now can help prevent irreversible hearing damage and improve the long-term health and productivity of workers in this high-risk industry

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