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Research Paper

Hazard Profile in Landscaping: Determination of Operators Noise Exposure for Work Process Safety

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Abstract: The first step in dealing with noise in the workplace is to identify the nature, processes, and areas where excessive noise exposure occurs, regardless of the use of hearing protection. In this study, the intensity of noise emitted by lawnmowers operated by groundskeepers in Abeokuta, Nigeria, was measured and evaluated under the National Institute for Occupational Safety and Health (NIOSH) recommended workplace exposure limit using a digital noise meter (Model Benetech GM 1351). The study observed a range of 85.78-90.55 dBA for an 8-hour TWA. The lawnmowers evaluated were 100% unsafe for noise exposure at work. This, therefore, required the effective use of personal protective equipment by workers to protect their hearing.

Keywords: *Exposure, noise, hearing, occupation, safety*

Introduction

In every work environment, there is a predominant and potentially dangerous problem (Azodo *et al*, 2018). Safety and health risk assessment typically begins with identifying the nature, operations, and areas that may be at risk and providing appropriate control measures to create an ideal safe workplace. The classification of noise as hazardous at work is a function of a combination of its frequency, intensity, and duration, with due regard to worker safety and health. Although noise is associated with work processes involving mechanised equipment and tools, it is often one of the most common preventable occupational health hazards prevalent in various occupational dispensations.

Groundskeepers's work routines include the use of mechanized equipment and tools in their mowing and trimming duties (Balanay *et al*. 2016; Bureau of Labour Statistics, 2014; OSHA, 2015). Studies have found that power tools produce continuous noise that may be less intense when compared to intermittent, regular, and irregular noise sources. Chung *et al*. (2012) expressed that exposure to continuous noise carries a greater risk of hearing loss than intermittent exposure, even if the mean range in A-weighted decibels is similar. Exposure to noise levels well over the established exposure standard could be harmful to exposed workers (Plontke and Zenner, 2004). For any workplace exposed to noise, there are established guidelines on the limit of A-weighted equivalent sound pressure level (LAeq) and exposure time for a 100 percent dose of noise that an unprotected worker should be exposed to in the work environment. Given the focus of this study, Table 1 shows the National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA), and Federal Environmental Protection Agency (FEPA) specifications for relative noise exposure limits for exposure. From Table 1, it can be seen that the noise intensity varies inversely with the duration of exposure concerning the hearing safety of workers. The reassessment and confirmation of occupational noise exposure at or above which noise levels are classified as hazardous by NIOSH is 85 dBA as an 8-hour time-weighted average (NOISH, 1998).

Noise, whether irregular, intermittent, or statistically random, changes the air pressure in the natural environment that is transmitted to the ear by sound waves. The received sound waves are then converted into electrical signals by sensitive hair cells called cilia in the inner ear or cochlea. These signals or nerve

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impulses are transmitted from the auditory nerve to the brain and interpreted as sound. The properties of noise that are important in the workplace are frequency, sound pressure, sound power and temporal distribution. The classification of noise as dangerous is a combination of frequency, noise intensity and duration that can lead to permanent hearing loss. Concerns about the impact of noise on workers as a result of intensity and time distribution are impaired communication, problems concentrating, stress from overwork, safety risks, productivity and profitability, acoustic shock and ototoxic chemicals. These effects contribute to accidents and injuries in the workplace by making it difficult for workers to hear warning signals.

Table 1. NIOSH, OSHA and FEPA specification for noise exposure limits for a 100% noise dose

A-weighted equivalent sound pressure level (dBA)		Noise exposure duration (hours)
NIOSH	OSHA and FEPA	
85	90	8
88	95	4
91	100	2
94	105	1
97	110	0.5
100	115	0.25

Source: NOISH, 1998; FEPA, 1991; OSHA, 1983

Noise exposure is one of the most common health problems in the workplace. Every year, thousands of workers are exposed to workplace noise hazards that result in preventable hearing loss. Statistical reports on noise exposure at work are not available for most developed and non-developed countries; Tips on the status of exposure to noise at work in countries such as South America, Africa and Asia were summarized from various studies that Nelson *et al*. carried out in these countries Nelson *et al*., 2005. with high noise exposure at the workplace. Studies on occupational noise exposure conducted in various professional organizations in Nigeria included: automobile assembly (Oleru, 1980), textile mill (Oleru *et al*., 1990 ; Osibogun *et al*., 2000), cable and wire production industry (Anjorin *et al*., 2015), wood processing factory (Anjorin *et al*., 2015), sawmill (Eziyi *et al*., 2015), soft drink- Bottling industry (Oyedepo and Saadu, 2010), tobacco industry (Oyedepo and Saadu, 2010), mineral crushers (Oyedepo and Saadu, 2010), beer brewing and bottling industry (Oyedepo and Saadu, 2010), sack manufacturing industry (Ismaila and Odusote, 2014). Other areas of noise investigation were traffic noise (Onuu, 1992), environmental noise (Adeke *et al*., 2018; Akinkuade and Fasae 2015; Anomohanran, 2013; Oyedepo, 2012; Ibhadode *et al*., 2018) and generator noise (Azodo and Adejuyigbe, 2013; Azodo *et al*., 2018; Otutu, 2011). The hazard profile in landscaping must be established to determine the acoustic exposure of the operator to the safety of the work process. Therefore, in this study, the maximum output intensity of noise emanating from a lawnmower used by the groundskeeper at Abeokuta and the associated safe exposure level were evaluated using the combination of noise exposure levels and duration criteria for a recommended standard occupational exposure limit.

Materials and Methods

This study was conducted to measure and evaluate the intensity of noise emitted by lawnmowers to represent the noise exposure levels of operators whose 8-hour TWA noise exposure may be 85 dBA or more. Physical measurements were carried out for the quantitative assessment of noise pollution from lawnmowers at groundskeepers in Abeokuta, Nigeria. The design instrument used for data collection was a digital noise level meter (DNLM) (model Benetech GM 1351). The DNLM operates with an A-weighted frequency in the frequency range of 31.5 to 8 kHz and measures a sound level in a range of 30 to 130 dBA. The consistency of the sound level measurements was made possible by the precise internal calibration of Benetech's DNLM and set to a slow response corresponding to a time constant of 1 s. The resolution setting of the digital noise level meter was 0.1 dB with an accuracy of ±1.5 dB. A total of 14 lawnmowers were used by the groundskeepers, five of which were weed killers, seven push lawnmowers and two tractor lawnmowers. To assess and record noise levels, each of the 14 lawnmowers evaluated in this study was assigned an alphanumeric code from G1 to G14. A digital sound level meter carrier has been designed to be carried by the worker during his work process. The improved design attached the DNLM to the worker's clothing with the microphone close to the ear. Measurements were taken and recorded after an exposure time interval of 5 minutes every hour for each of the designated lawnmowers at the maximum option setting. Working hours were 8:00 a.m. to 12:00 p.m. (4 hours) and 1:00 p.m. to 3:00 p.m. (2 hours). The collection of data on the noise level of the individual groundskeepers extended over a total period of five weeks. This resulted in a total of 6 measurements per day for 6 hours of work and a total of 30 measurements per participant for the 5-week work exposure. The A-weighted equivalent sound pressure level (LAeq) has been calculated to give a single constant noise level value representing an equivalent total sound energy to which groundskeepers are exposed while on duty during the assessment period. This calculation was in the form of an A-weighted equivalent sound pressure level (LAeq) using Eq. (1) below (Oyedepo *et al*., 2019).

$$L_{Aeq} = 10\log_{10}\left[\frac{1}{N}\sum_{i=1}^{N}\left(anti\log\frac{L_{Ai}}{10}\right)\right] \quad (1)$$

Where
L_{Aeq} = A-weighted equivalent sound pressure level
L_{Ai} = A-weighted sound pressure level in dB
i = 1, 2, 3… N
N = total number of measurements

In addition, the daily duration of each groundsman's working time was recorded for an 8-hour conversion representing the daily noise exposure level using the equivalent International Standards Organization (ISO) (3) formula. The time-weighted average (TWA) noise level and noise dose were calculated to indicate workers' exposure to occupational noise, normalized to 8 hours (hrs) per day, taking into account the calculated A-weighted equivalent sound pressure level (LAeq) (equation 4) and the exposure time during the work process (Eq. 2). Occupational noise exposure, which is a combination of exposure level (L) and duration (T), was assessed using the expression (NOISH, 1998).

$$T_n(\text{min}) = \frac{480\ (min)}{2^{(L-85)/3}} \quad (2)$$

Where
L = The combination of exposure level
T_n = Exposure duration for which noise at this level becomes hazardous
3 = the exchange rate

Whereas the daily dose (D) of the noise exposure for each of the sessions at different noise levels obtained was calculated according to (NOISH, 1998) the following formula:

$$D = \left[\frac{C_1}{T_1} + \frac{C_2}{T_2} + \cdots + \frac{C_n}{T_n}\right] \times 100 \quad (3)$$

Where
C_n = Total time of exposure at a specified noise level, and
T_n = Exposure duration for which noise at this level becomes hazardous
The daily dose was converted into an 8-hour TWA using (NOISH, 1998) the formula

$$TWA = 10.0 \times log\left(\frac{D}{100}\right) + 85 \quad (4)$$

The assessment of noise intensity levels from lawnmowers on groundskeepers for safety and health risk analysis was performed with reference to the revised recommended standard criteria for noise exposure at work from the National Institute for Occupational Safety and Health (NOISH, 1998) (see Table 1). The NIOSH specification for noise exposure limits for a noise dose of 100% was adopted for the safety analysis in this study because OSHA amended its noise standard to include specific hearing protection program provisions for occupational exposures at 85 dBA or greater (Department of Labour, 1981; US Department of Labour, 1983). The amended OSHA noise standard does not cover all industries (NOISH, 1998). In addition to comparing excessive risk estimates developed by the National Institute for Occupational Safety and Health (NIOSH), the Environmental Protection Agency (EPA), and the International Standards Organization (ISO) for material hearing damage caused by an average daily exposure to noise in the workplace over a period of 40 to 30 years. According to NIOSH, working years resulted in a higher excess risk percentage (NOISH, 1998). The time-weighted average (TWA) noise levels obtained for each of the workers were classified as safe and unsafe noise exposure levels according to the interpretation guide in Table 1.

$$Spl = \frac{\sum(wf_i.t_i)}{\sum t_i} \in [0,1] \qquad (1)$$

$$\begin{bmatrix} Spl_{unsafe} \text{ with } wf_i = \begin{bmatrix} 1 \; if \; I_{sound\ level} > I_{85\ dBA} \\ 0 \; if \; I_{sound\ level} \leq I_{85\ dBA} \end{bmatrix} \\ Spl_{safe} \text{ with } wf_i = \begin{bmatrix} 1 \; if \; I_{sound\ level} < I_{85\ dBA} \\ 0 \; if \; I_{sound\ level} \geq I_{85\ dBA} \end{bmatrix} \end{bmatrix}$$

Where

Spl = Sound pressure level
t_i = Time in hours
wf_i = A-weighting factor variable which depends on $I_{sound\ level}$ values

Table 4. Acoustic risks and safety analysis interpretation of the noise intensity level from lawnmowers on groundskeepers for 85 dBA as an 8-hour TWA

TWA noise levels	85 dBA as an 8-hour TWA exposure level interpretation
≤85dBA	safe noise exposure levels
≥85dBA	unsafe noise exposure levels

Results and Discussions

Table 5 shows the noise level measurement recorded with the noise level meter and the evaluated noise descriptors of the 14 lawnmowers used by the groundskeepers. The average range of the measured noise level (Lav) was 94.11 - 99.8 dBA. The lowest noise level measured (Lmin) was 86.1 dBA, while the highest (Lmax) was 109.9 dBA. The noise descriptor ranges were 89.7–95.46 dBA, 93.2–100.25 dBA, 97.19–105.31 dBA and 95.16–102.89 dBA for the 10th percentile (L10), the 50th percentile (L50), the 90th percentile (L90) and the A-weighted equivalent sound pressure level (LAeq) respectively (Table 5). The assessment of the potential for lawnmower occupational hearing loss in lawnmowers was performed by reference to the National Institute for Occupational Safety and Health's revised recommended standard occupational noise exposure criteria for a combination of noise exposure levels and duration criteria. This was assessed using the NIOSH recommended occupational noise exposure limit of 85 A-weighted decibels (85 dBA) for an 8-hour time-weighted average exposure period (8-hour TWA). The Time-Weighted Average (TWA) criterion is the measured noise levels and safety levels at the workplace for each worker. If a worker's exposure exceeds 85 dBA on the 8-hour time-weighted average (TWA), this simply means that the exposure level is unsafe, and therefore a hearing loss prevention program is required. Analysis of the data obtained for five weeks assessment presented in Table 5 showed that the occupational exposure levels for the assessed groundskeepers were all above the NIOSH recommended exposure limit for occupational noise exposure of 85 decibels, A-weighted, as an 8-hour time-weighted average (85 dBA as an 8-hour TWA).

The range of an 8-hour time-weighted average over five (5) weeks was 85.78 - 90.55 dBA. The high baseline noise intensity observed in this study at 85 dBA as an 8-hour TWA is similar to other studies that have assessed workplace noise exposure (Kelly *et al*, 2012; Lao *et al*., 2013). Due to the health effects of the intensity and duration of worker exposure to noise, an analysis of individual users' safety regimens for safe to unsafe operational characteristics (equal to or above 85 dBA) revealed a 100% unsafe level of occupational noise exposure among participants as a total time-weighted average (TWA) The Noise levels measured for the mower evaluated exceeded 85 dBA. This is of concern as continuous and prolonged exposure to excessive or repetitive sound above 85 dB in everyday work life is potentially dangerous, often resulting in hearing loss (Azodo & Adejuyigbe, 2013; Azodo *et al*., 2018; Green and Anthony, 2015). The damaging effect of noise is insidious and only becomes apparent when the victim has been impaired over the years while maintaining normal hearing, as dangerously loud noises are hazardous even if they are not painful, and pain only occurs at 120-140 decibels (Roland-Mieszkowski, 1994).

Table 5. Average noise descriptors from the lawnmowers to the groundskeepers over a period of five weeks

Groundskeepers (G)	L_{max}	L_{min}	L_{10}	L_{50}	L_{90}	L_{av}	L_{Aeq}	T_n	DOSE (%)	*TWA*
1	102.4	90.7	91.87	95.95	101.5	95.92	97.59	6.86	1373	86.37
2	109.9	90.6	94.02	100.25	105.31	99.8	102.89	27.75	5551	90.55
3	101.8	90.4	91.66	95.35	101.71	96.18	97.67	7.01	1403	86.40
4	104.6	91.8	91.89	93.20	104.42	96.73	99.97	11.42	2284	87.28
5	98.7	89.9	91.16	95.35	98.07	94.68	95.47	4.17	834	85.83
6	102.1	91.8	92.43	95.65	100.39	95.89	97.14	5.98	1197	86.20
7	100.2	91.4	91.94	96.00	97.59	95.68	96.33	5.31	1061	86.06
8	101.0	94.4	94.76	95.95	100.55	96.78	97.44	6.04	1208	86.21
9	99.7	86.1	89.7	94.75	98.08	94.11	95.52	4.02	804	85.80
10	100.5	93.9	94.35	98.00	99.96	97.37	97.91	7.17	1435	86.43
11	98.0	90.4	92.11	95.05	97.19	94.67	95.16	3.89	778	85.78
12	104.4	94.2	95.46	97.95	102.96	98.56	99.76	11.24	2248	87.25
13	101.4	90.1	91.18	97.85	100.68	97.09	98.25	7.74	1548	86.55
14	103.9	92.9	92.9	98.70	102.19	98.18	99.77	11.16	2233	87.23

Conclusion

In this study, the intensity of the noise emitted by a lawnmower used by the groundskeeper was measured and the associated safe exposure level was assessed using the combination of noise exposure levels and duration criteria for a recommended occupational standard. Analysis of the data obtained using the criteria for a recommended occupational exposure standard revealed that the occupational exposure levels for the groundskeepers assessed were all above the NIOSH recommended occupational noise exposure limit of 85 decibels, A-weighted, as an 8-hour time-weighted average (85 dBA as an 8-hour TWA). Due to the health effects of the intensity and duration of worker exposure to noise, an analysis of individual users' safety regimens for safe to unsafe operational characteristics (equal to or above 85 dBA) revealed a 100% unsafe level of occupational noise exposure among participants as a total time-weighted average (TWA) The Noise level of the evaluated lawn mower exceeded 85 dBA. This requires proactive safety measures through the use of personal protective equipment such as earmuffs or earplugs for workers' hearing protection.

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