EVALUATION OF NOISE POLLUTION FROM A WELDING WORKSHOP WITH A MAXIMUM NOISE LEVEL OF (96.91±0.83) dBA

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ABSTRACT

In residential areas, it is pertinent to investigate the coverage distances of the adverse effects of environmental noise of a work place around it such as a welding workshop. This research work presents an evaluation of residential noise pollution from a welding workshop with a maximum noise level of (96.91 ± 0.83) dBA. Measurements of noise levels were carried out using a sound level metre while a measuring tape was used for distance (x) measurements. The average noise levels of the workshop (L_{av}) and the background noise levels (L_B) were taken from x = 5m to x = 60m. The workshop noise levels, $L_{W(Measured)}$ were evaluated and a model, $L_{W(Modeled)}$ was developed by using Linear Regression Method. $L_{W(Modeled)}$ and $L_{W(Measured)}$ were compared. The results revealed that $L_{W(Measured)}$ had potential adverse health effects on the residents in the area beyond x = 55m. This is because at x = 55m, $L_{W(Measured)}$ = 59.37 dBA instead of 55 dBA safe level by World Health Organization (WHO). It was observed that the background noise level L_B were also above the WHO tolerant level of 55 dBA for a non-work environment. The results indicated that the maximum noise level of the welding workshop was (96.91±0.83) dBA (i.e. L_w at x = 0m). It was also shown that there was no significant difference between $L_{W(Measured)}$ and $L_{W(Modeled)}$. It is recommended that this type of workshop should be located beyond a distance of 55m from the residential areas.

INTRODUCTION

Community noise has negative effects on human health and well-being. It is a threat to public health. Community noise is described by World Health Organisation (WHO) as environmental, residential or domestic noise (Ekott *et al*., 2020; WHO, 1999). The most important sources of community noise are air, rail and road traffic, neighbourhood, municipal work, and the construction plant, among others. Usually, noise from neighbourhood originates from building and installations associated with the food preparation business like cafeterias, restaurant, and discotheques; from recorded or live music; from playgrounds and car parks; from sporting events including motor sports; and from household animals for example barking dogs (Ekott and Akpan, 2020). The major sources of indoor noises include aeration systems, home appliances; office machines, and neighbours, among others (Ekott *et al*., 2020,).

The industrial noise is one of the most discomforting sources of noise. In the United States of America, the Environmental Protection Agency (EPA) identified noise as a hindrance since in the 1970s (Menkiti and Ekott, 2014). As with all pollutants, noise degrades the value of our environment and is known to produce various negative effects both on structures and on humans. Noise has escalated to the point where it is currently the most important peril to the superiority of our existence. The increase in noise can be attributed to the ever increasing number of people in the globe and the growing levels of economic affluence (Menkiti, 2001).

Analysis has showed that noise of workshops/factories account for about 80% noise pollutants. The level of a noise to induce annoyance depends upon many of its physical characteristics, including its sound pressure level and spectral characteristics, as well as the variations of these properties over time. In this context, noise is defined as unpleasant sound (Schmidt, 2005). However, noise can be described as the unwanted sound in the unwanted location at the unwanted occasion. The degree of “unwantedness” is usually a psychological issue since the effects of noise can range from temperate irritation to everlasting hearing loss, and may be rated in a different way by special observers. This is why it is often exigent to establish the benefits of dropping a specific noise. Noise does affect the inhabitants, humans and fauna, among others, in the natural environment. Some definite places influence noise contacts; so it is invasive that it became difficult to run away from it. The public opinion polls almost constantly rank noise in the list of the most bothersome residential irritations. Community noise intrusions like traffic noise can obstruct speech communication, interfere with sleep and relaxation and disturb the capacity to perform difficult tasks (Kiely, 1998).

Investigations indicated that children exposed to noise during classes experienced problem with various cognitive developmental delays in addition to words discrimination. Specifically, the writing learning mutilation called dysgraphic is usually related to stress on environment during classes (Klatte, *et al*, 2013; Seabi, 2013; Clark *et al.*, 2013; Stansfeld *et al.*, 2005). In addition, the consequence of elevated levels of noise on small children has been found to be related to physical health damage (Goran, 2008).

Noise has been connected to vital cardiovascular health risks. More current studies have recommended that noise levels of 50 dB(A) at night may also increase the risks of myocardial infarction by constantly enhancing production of cortisol (Essiett *et al*., 2010). The British Columbia Work's Compensation Board has set 85 dB as its highest tolerant level in the work place. Above this limit hearing protection should be used. It states that the threshold of pain is attained at 120 dB and it classifies 140 dB as excessive hazard level. WHO's safety noise levels are similar while EPA of Nigeria tends to have even a stricter standard of 70 dB as a maximum safe level of noise in work place. They have given the safe level around home to be 50 – 55 dB (Ekott and Menkiti, 2015; Akpan, *et al.,* 2019).

High noise levels may reduce the accuracy of the work being undertaken rather than the quantity. Steady noises appear to have little effect on work performance unless the weighted noise level exceeds about 90 dB (Davis and Cornwell, 1991). Researchers have shown that constant noise above 55 dBA causes serious annoyance and above 50 dBA moderate annoyance at home (WHO, 2007). In a non-work place and for health and safety purposes, 55 dBA is set as a safety noise level for outside and 45 dBA inside. Hospital and school permissible levels of noise are 35 dBA (WHO, 1999; Ekott *et al*., 2019). In Britain, the Ministry of Agriculture regulations established in January 2002 states that propane cannons can be no closer than 150 metres from residential areas, and 100 metres from other kinds of noise makers. These machines generate noise at levels between 115 and 130 dB. At 100 meters, the noise generated is above 80 dB, and greater than 75 dB at 150 metres, which is greater than the specified safe levels in residential areas. Beyond 80 dB, is near to the level at which ear protection should be used (Menkiti and Ekott, 2014).). Noise beyond harmless levels leads to numerous health impacts which include high blood pressure, annoyance, sleep loss, stress, hearing impairment, loss of productivity and the ability to concentrate, among others (Ekott and Akpan, 2019). A study by Obisung *et al.* (2016) shows that sleep interference by noise causes great annoyance to many people. A study by Halperin (2014) shows that sleep is an important modulator of cardiovascular function. Intermittent or impulsive noises are particularly disturbing. Because of differences between locations and people, it is not easy to establish the level of noise which will not cause sleep interference (WHO, 2009 and Kiely, 1998).

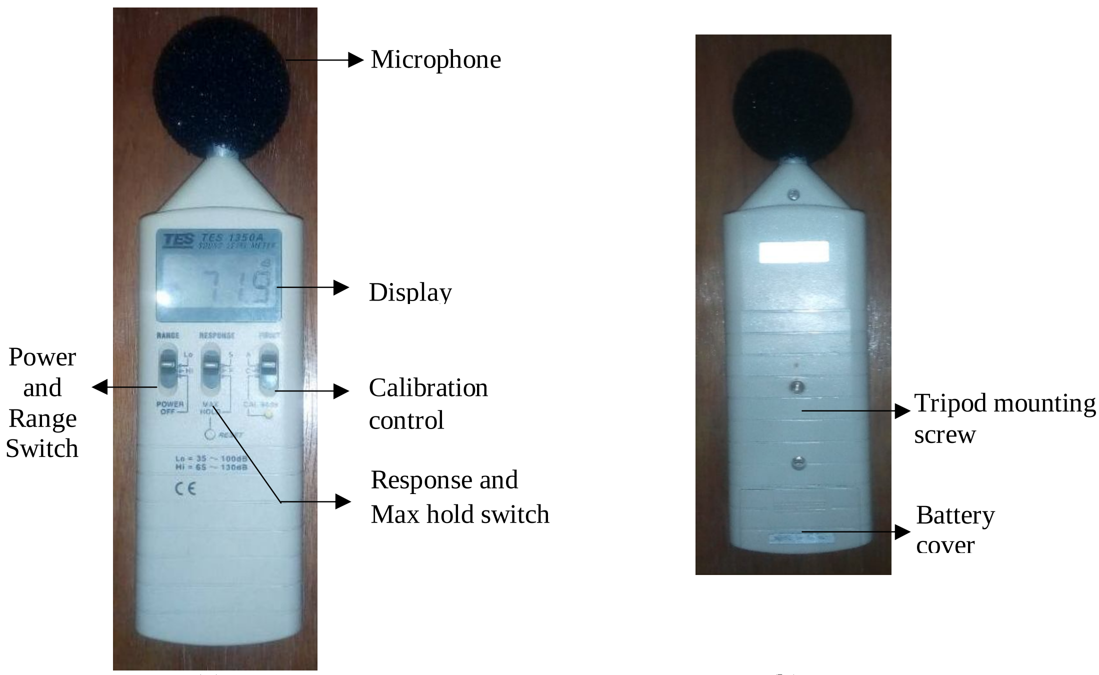
Consequently, the study of noise is highly imperative so as to create more awareness on the adverse effects of noise on the community for the betterment of our society. In this work, the evaluation of residential noise pollution from a welding workshop with a maximum noise level of (96.91±0.83) dBA was carried out.

MATERIALS AND METHODS

Measurement of Noise Levels with Distance

The noise level measurements were conducted in an arc welding workshop located at Ekpri Nsukara, Nwaniba Road, Uyo, Akwa Ibom State, Nigeria. The measurements were made using the sound level meter model TES 1350A with ½ inch Electret condenser microphone (TES Electrical Electronic Corp., Taiwan). It has low and high measuring ranges 35 to 100 dB and 65 to 160 dB respectively. Also, it is equipped with a built-in calibration check (94.0 dB), tripod moving and analogue DC/AC conditional output of 10 dB. It has a weight of 210 grammes (including a 9 V battery) and completed with hard vinyl case. It also has electronic circuit and readout display. The microphone detects the small air pressure variations associated with sound and changes them into electrical signals. These signals are then processed by electronic circuitry of the instrument. The readout displays the sound levels in decibels. The sound level meter measures the sound pressure level at one instance in a particular location. The measurements were taken by setting the sound level meter to an A-weighting network in all the sampling locations. The sound level meter was calibrated before and after each use. The manufacturer's manual gave the calibration procedure. During the noise level measurements, the sound level meter (microphone) was positioned at a distance of 5 m from the main source (an electric power generator) at 1.2 m above ground level (EC, 1986).

Distances of 5 m intervals were taken using the measuring tape. Noise level measurements were taken by setting the Sound level meter response to slow since the source of noise was stationary, and low range settings was selected since the background noise was not above 60 dBA. The data obtained were statistically analysed, compared with the WHO and other standard noise levels. The workshop noise levels, $L_{W(Measured)}$ were evaluated and a model, $L_{W(Modeled)}$ was developed by using Linear Regression Method. The modeled noise levels, $L_{w(Modeled)}$ were compared with the measured noise levels, $L_{W(Measured)}$.



(a) (b)

Figure 1: (a) Front view of the sound Level meter (b) Back view of the sound level meter
Source: TES- 1350A Instruction Manual

Calculating the Welding Workshop Noise Level, $L_{W(Measured)}$

After measuring the background noise level and the total noise level (L_{av}), Welding Workshop noise which is working hour noise level, $L_{W(Measured)}$, was calculated by using Equation (1) (Cunniff, 1977; Ekott *et al., 2018):*

$$L_{W(Measured)} = 10\log10\left[10^{0.1L_{av}} - 10^{0.1L_B}\right] \quad 1$$

RESULTS AND DISCUSSION

The results of the survey are presented in Tables (1-2) and Figures (2–5).

Table 1: Noise levels with distance measurements

x (m)	L_B (dBA)	L_{av} (dBA)	$L_{W(Measured)}$ (dBA)
5	66.5	94.63	94.62
10	63.3	90.06	90.05
15	62.8	86.24	86.22
20	62.4	81.55	81.50
25	61.3	77.17	77.06
30	59.9	74.89	74.75
35	60.1	70.14	69.69
40	59.7	67.57	66.80
45	58.8	65.19	64.66
50	57.5	62.26	60.49
55	55.9	60.98	59.37
60	55.2	56.79	51.66

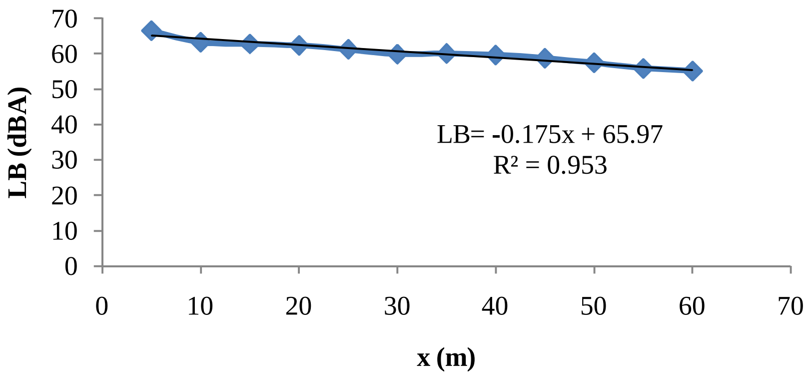


Figure 2: Characteristics of L_B with x

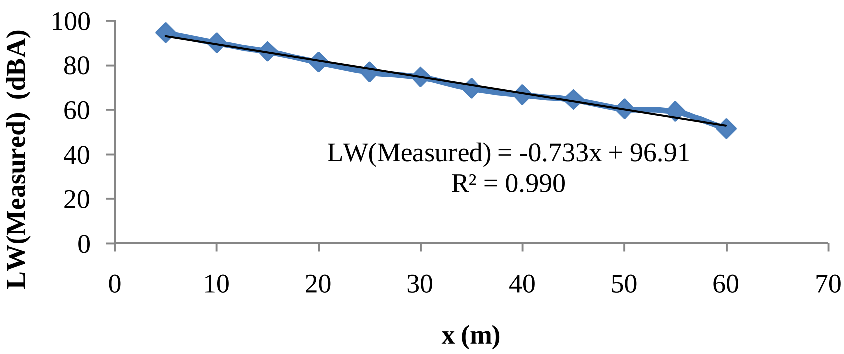


Figure 3: Characteristics of $L_{W(Measured)}$ with x

Table 2: Comparison of $L_{W(Measured)}$ and $L_{w(Modeled)}$

x (m)	**$L_{W(Measured)}$ (dBA)**	**$L_{w(Modeled)}$ (dBA)**	**Difference between $L_{W(Measured)}$ and $L_{w(Modeled)}$ (dBA)**
5	94.62	93.245	1.375
10	90.05	89.580	0.470
15	86.22	85.915	0.305
20	81.50	82.250	-0.750
25	77.06	78.585	-1.525
30	74.75	74.920	-0.170
35	69.69	71.255	-1.565
40	66.80	67.590	-0.790
45	64.66	63.925	0.735
50	60.49	60.260	0.230
55	59.37	56.595	2.775
60	51.66	52.930	-1.270

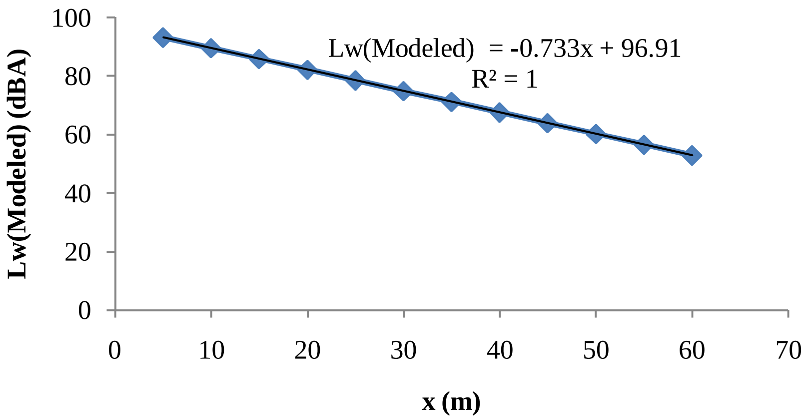


Figure 4: Characteristics of $L_{w(Modeled)}$ with x

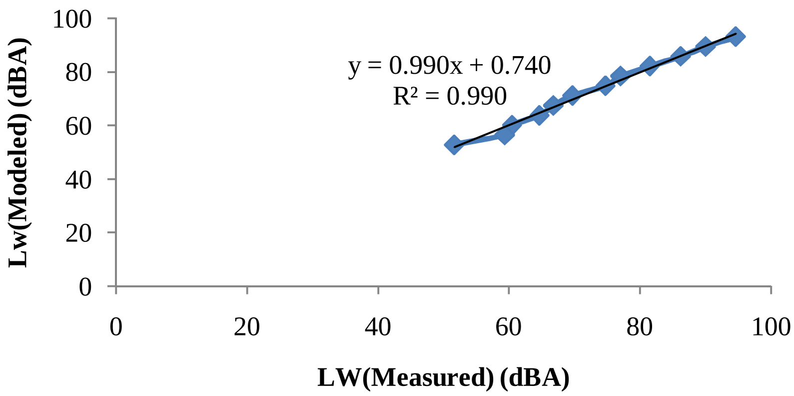


Figure 5: Comparison of modeled noise levels, $L_{w(Modeled)}$ and measured noise levels, $L_{W(Measured)}$ of the welding workshop

The results presented in Tables (1-2) and Figures (2 – 5) showed that the welding workshop is located in a noisy area. This is because the measured background noise levels (L_B) of the area were above the WHO tolerant levels of 55 dBA for residential area (WHO, 1999). For instance at a distance of 5m from the workshop, the background noise level was 66.5 dBA in the direction of measurements. A background acoustic level of 55.2dBA was recorded at a distance of 60m from the main source of noise (the electric power generator). The characteristics of the background noise level, L_B with distance (Figure 2) give a linear regression equation in dBA as presented in equation (2):

$$L_B = -0.175x + 65.97;\ R^2 = 0.953 \quad (2)$$

In equation (2), the co-efficient of determination, $R^2 = 0.953$. This means that even the L_B and x and strongly correlated in the direction of measurements. The measured background noise levels therefore indicated that the area was not conducive for living. The results of the investigation showed that the L_{av} and the $L_{W(Measured)}$ have approximately the same frequency up to a distance of about 45 m away from the generator. This simply means that they have almost the same frequency up to the 45 m. The workshop noise affects the residents beyond a distance of 55 m. This is because at x = 55 m, $L_{W(Measured)}$ = 59.39 dBA; instead of 55 dBA for a non-work place (WHO, 1999). The workshop of this type has to be located beyond 55 m from people's residence. This is because at x = 55 m, $L_{W(Measured)}$ = 59.37 dBA.

Figure 3 gives the characteristics of $L_{W(Measured)}$ and x. The linear fitting model in dBA obtained from the analysis is presented in equation (3):

$$L_{W(Measured)} = -0.733x + 96.91 \quad (3)$$

Considering the error term, $\in_w$, equation (3) becomes:

$$L_{W(Measured)} = -0.733x + 96.91 + \in_w \quad (4)$$

At source, that is at x = 0, equation (3) becomes:

$$L_{W(Measured)} = 96.91 \text{ dBA} \quad (5)$$

Equation (5) gives the maximum noise level of the workshop. From the analysis, the intercept which is the maximum noise level has a standard error of 0.83 dBA. The linear model has a slope (or attenuation coefficient) of (-0.733±0.02) dBA^{-1}. The results of the investigation also show that $L_{W(Measured)}$ and x are strongly correlated with the coefficient of determination, R^2 = 0.990. Equation (6) is the linear fitting model in dBA developed from the workshop measured noise levels. It has attenuation coefficient of of -0.733 dBA^{-1} and a maximum noise level of 96.91 dBA. It is denoted by $L_{w(Modeled)}$ and has a coefficient of determination, R^2 =1. Hence, Table 2, Figure (4) and equation (6) show that there is no significant difference between $L_{W(Measured)}$ and $L_{W(Modeled)}$.

$$L_{w(Modeled)} = -0.733x + 96.91 \quad (6)$$

Therefore, equation (6) can be used in place of the equipment to evaluate the noise level of this kind of noise source. Figure 5 shows the comparison of modeled noise levels, $L_{w(Modeled)}$ and measured noise levels, $L_{W(Measured)}$ of the welding workshop. It as a linear regression equation as presented in equation (7).

$$y = 0.990x + 0.740;\ R^2 = 0.990 \quad (7)$$

In equation (7), y is the modeled noise level, $L_{w(Modeled)}$ and x is the measured noise level, $L_{W(Measured)}$ of the welding workshop. The regression model, equation (7), has a coefficient of determination, R^2=0.990. This means that there is no significant difference between $L_{w(Modeled)}$ and $L_{W(Measured)}$.

CONCLUSION

It is concluded from the investigation that the noise levels $L_{W(Measured)}$ emitted during the hours of arc welding workshop had adverse health effects on the people beyond a distance of 55 m because at x = 55m, $L_{W(Measured)}$ = 59.37 dBA instead of 55 dBA safe level by WHO. The measured background noise levels, L_B showed that the welding workshop was not the only source of noise in the area, as all the L_B values were above the WHO tolerant level of 55 dBA for a non-work place. The maximum noise level of the welding workshop was (96.91±0.83) dBA (i.e, it is obtained from the regression equation in Figure 4). The environmental noise levels of the area were beyond the tolerant level of 55dBA for residential areas. The safe distance for locating this type of workshop should be beyond a distance of 55 m from the residential areas. This is because beyond the distance of 55 m, the $L_{W(Measured)}$ would be less than the 59.37 dBA recorded at x = 55 m. It is observed that there is no significant difference between $L_{W(Measured)}$ and $L_{W(Modeled)}$.

RECOMMENDATIONS

It can be recommended from the above investigation that:

- This type of workshop should be located beyond a distance of 55 m from the residential areas.
- The workers in the workshop should be advised to wear ear protectors.
- Environmental noise analysts should be consulted before establishing environmental disturbing system of this nature.

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