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Original Article

Evaluation and implication of noise and vibration levels to the operators and proxy population around selected block molding industries in Ibadan, Nigeria

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ABSTRACT

Introduction: Block-making industries owned by private individuals are cited in cities to utilize the existing market opportunity of supplying concrete blocks to developers. The study aimed to measure noise and vibration levels at selected block-molding industries and assess their health implications.

Methods: The study design involves twenty-five block molding industries randomly selected in the Ibadan metropolis. These industries voluntarily agreed to participate in the research, and measurements were done between January and May 2022. The noise and vibration levels were measured using a digital multi-function environmental meter, Model DT-8820, and a vibration meter, Model VM-6360, respectively.

Results: An overall mean noise level of 101.81 dB(A), 85.62 dB(A), 76.40 dB(A), 70.21 dB(A), 65.91 dB(A), and 63.61 dB(A) at 0, 10, 20, 30, 40 m, respectively, away from the source to residential buildings were obtained. Results indicate that the noise level at 0 m and 10 m exceeded the occupational noise level standard. The results obtained for the vibration levels on the hand of the operators ranged between 42.2 ms^{-2} to 59.7 ms^{-2} and these exceeded the occupational vibration level standard. This may indicate that the operators of the block-molding machine may be exposed to various adverse health detriments due to high noise and vibration levels at their workplace.

Conclusion: The study recommends using safety gadgets such as hearing protection and anti-vibration gloves for workers in these industries. Moreover, environmental education and awareness should be carried out, and residential structures should be situated at least 20 m from the block industries.

Keywords: Block Molding Industries, Health Effect, Ibadan, Noise Level, Vibration Level

Introduction

Noise in the environment includes both wanted and unwanted sounds that can impact human health and well-being.[1,2] The sources of noise pollution include street traffic, aircraft, marketplaces, grinding machines, railroads, industry, construction, consumer products and others.[3] The effect of noise on humans can be severe, such as hearing loss, sound impairment, sleep disruption, disturbance and communication interference. Noise level hinders communication between workers in industries, and the physical, physiological and psychological effects may also be pronounced on them and result in low productivity.[4,5,6] In this age of rapid urbanization, there is an ever-increasing need and demand for shelter, and houses constructed with concrete blocks are predominant buildings. Small-scale block-making factories owned by private individuals are cited in cities to utilize the existing market opportunity of supplying concrete blocks to developers. Generally, block molding machines operate on vibration techniques to commercialize building blocks. The vibrated block molding machine is preferred to the manual molders because its operations require fewer personnel coupled with the advantage of mass production of stronger blocks. In most cities of Western Nigeria, block industries and residential buildings are located within short distances from one another.

Many studies on industrial noise and the assessment of the adverse health effects on industrial workers have been reported. The health effects of exceeded noise levels of concern include noise-induced hearing loss (NIHL), negative social behavior and annoyance reactions, and cardiovascular diseases.[7] Also, recent studies conducted by psychiatrists and psychologists have pointed out a link between noise and the physical health of humans. A noisy environment can cause adverse effects such as speech interference, annoyance, fatigue, sleep interference and emotional distress.[7] One of the most common hazards threatening occupational health and safety is excessive exposure to noise, which can result in permanent hearing loss.[8] The quantities that are very effective for determining the level of hearing loss due to noise are exposure period, noise level, workers' age, and physical condition (existence of other illnesses, etc.). The capacity of the ear to respond to the noise around is dependent on time; when the exposure is prolonged for an extended period, it tends to damage the listener's inner ear. It is common knowledge that noise can disturb sleep. The body rejuvenates through sleep; adequate sleep produces good well-being. Night-time noise is a stressor on the body and can initiate an autonomic response with increased blood cortisol, adrenaline and noradrenaline levels. The World Health Organization (WHO, Night Noise Guidelines for Europe) recommended a mean night-time noise exposure limit of 30 dB(A), which corresponds to the sound from a quiet street in a residential area and exposure to levels of night-time noise more significant than 30 dB(A) were reported to result in sleep disturbances and insomnia. Carol showed in her work that "the flow-on effect from these disturbances includes increased fatigue and decreased performance along with a possible negative effect on temperament".[9]

The study conducted by Kisku and Bhargara on the primary sources of noise-producing machines of a thermal plant revealed (70.37 dB(A)) and (95.91 dB(A)) at the lowest and highest mean noise, respectively; these were found in the control room and at F.D fan. Compressors produced the next noise value (89.98 dB(A)), close to the highest mean value.[10] Anjorin et al. examined the noise levels in two selected processing and manufacturing industries and showed that in the selected manufacturing industry, the generator produced the highest noise level of 95.39 dB(A), and the lowest was found in the Coiling machine at 82.84 dB(A). In contrast, in the selected processing industry, the Circular saw machine generated the highest noise of 117.50 dB(A), and the lowest noise recorded in the tractor machine was 100.72 dB(A). They concluded that the mean noise exposure level in the two industries is greater than 85 dB(A).[4] The result from this study is far above the recommended value according to the World Health Organization (WHO), and noise-induced hearing loss (NIHL) is a common ailment found among the workers of the studied industries and, by extension, in other industrial areas. In the last couple of decades, the zeal for preventing noise-induced health problems has grown, but vibration caused by a human is still placed at the second number.[11] Devices that generate induced vibration are globally recognized as a potential health hazard. This is one of the ways people are exposed to stress at work. Laszlo, Mandal and Srivastava investigated the vibration exposure of horticultural workers, which showed that the total vibration value ranged from 1.880 to 4.469 ms^{-2} (for the brush cutters), 3.915 ms^{-2} and 10.039 ms^{-2} (for the lawn movers) and 2.243 ms^{-2} and 4.777 ms^{-2} (for hedge trimmers) with the average exceeding the 2.5 ms^{-2} exposure action value and therefore concluded that this exposure could be the origin of vibration-induced injuries in the hands and arms of the workers.[11,12]

Also, Su et al. conducted a survey on hand-arm vibration syndrome among a group of tree fellers in a tropical environment, which showed a maximum vibration exposure value of 9.65 ms^{-2} and a mean value of 4.59 ms^{-2} in which the number of subjects exposed to A(8) of greater than 2.50 ms^{-2} was thirty, and from this, close to half of them got exposed to the A(8) of more than 5.00 ms^{-2}.[13] It was found that the tree fellers with neurological symptoms and finger coldness were exposed to higher levels of A(8) than those without the symptoms. The study also reported a higher prevalence of finger tingling, numbness and dullness among the tree fellers, consistent with the other reports from a tropical environment. The authors concluded their study by suggesting that "finger coldness and finger tingling, numbness and dullness are important symptoms for Hand-Arm Vibration Syndrome (HAVS) in a tropical environment which could be associated with the high level of vibration exposure and may indicate vascular and neurological damage due to hand transmitted vibration exposure". Exposure to hand-arm vibration, HAV, may lead to various medical symptoms. The inclusion of arms shows clearly as vibration-induced white finger (VWF) or hand-arm vibration syndrome (HAVS).

International Labor Organization (ILO) in 1977 itemised vibration as an occupational hazard and suggested that precautions be taken to guard industrial workers against vibration. Regulatory bodies must establish bases to ascertain the danger; when necessary, the exposure levels must be defined utilizing these bases. There must be control measures to maintain the noise levels within a permissible exposure limit. In Nigeria, the available guidelines for regulation and control of noise are provided by The National Environmental Standard Regulation and Enforcement Agency (NESREA).[14] The agency has the statutory role of protecting and developing the environment, biodiversity conservation and sustainable development of Nigeria's natural resources and environmental technology, including coordination and linking with relevant stakeholders in Nigeria and diaspora on the execution of environmental standards, regulations, policies, rules and guidelines. The maximum permissible noise limits of progressive or recurrent noise from a workshop or a factory to which an individual may be exposed, as given by the NESREA, is 85 dB(A) for a daily duration of 8 hours, 75 dB(A) for the factory environment and 50 dB(A) for residential buildings.

While studies have been conducted on occupational exposure to noise in industries in different countries, in the city of Ibadan, Nigeria, to the best of our knowledge, there is little or no attempt has been made to determine noise and vibration levels in the block-making industries despite their widespread locations and daily operations in the city. Therefore, this study was designed to measure and assess the noise and vibration levels from blocking molding industries to the workers and proxy populations to suggest possible effective control measures. In addition, the study could serve as baseline information for researchers interested in assessing the noise and vibration levels due to block molding industries in the city.

Methods

Block industries were randomly selected from twenty-five sites in the metropolitan city of Ibadan, southwestern Nigeria, between January and May 2022. This selection was premised on the fact that the Ibadan metropolis hosts the major quarry sites in southwest Nigeria because of the basement complex geological setting of the city that favors granitic rock mining, hence the establishment of block molding industries across the city. Moreover, Ibadan is widely known for its unique features, among which is the power base of Oyo State, Nigeria. It is also located on latitude 7^0 23 North and longitude 3^0 5 East of the Greenwich Meridian. Over the decades, Ibadan has been known as the largest city in West Africa and the second largest in Africa. The city is positioned within the tropical forest zone but near the boundary between the forest and the derived savanna. It is a metropolitan city covering a total of 3,080 km^2. It is a typical example of rapid expansion and urbanization in Nigeria. It is the third most densely populated city in Nigeria, with a population of more than 3 million.

The block-making industry owners gave their informed consent after engaging them on the purpose of the research; the selected industries voluntarily agreed to participate in the research. The noise level was measured using a digital multi-function environment meter (DT-8820). Measurements were done based on the procedures recommended by the Health Safety Executive (HSE) and International Standardization of Organisation (ISO); this device includes the function of a sound level meter. The multi-function environment meter also has an electric condenser microphone, a filter with a frequency range of 30 Hz- 10 kHz and a measuring range: A LO (low)- Weighting: 35-100 dB; A HI (High)- Weighting: 65-130 dB; C L.O. (low)- Weighting: 35-100 dB; C HI (High)- Weighting: 65-130 dB. A sound level meter comprises a microphone that connects the signal to a set of filters and amplifiers.[15] The microphone responds to sound pressure, producing a specific Sound Pressure Level (SPL) output. An SPL is the value reported when a sound measurement is collected. There are three different weighting scales used when measuring SPLs. The three scales are the A-, B-, and C- weighted scales. The A-weighted scale filters sound pressures based on how the human ear answers to different sounds at varying frequencies and accurately represents human hearing responses.[16] Sound pressure levels are recorded on a log scale and have the decibel unit (dB).

Noise levels were measured in the 25 selected block industries across Ibadan using a calibrated digital multi-function environmental meter, Model DT-8820. The sound level meter was adjusted to the A-weight level, measuring noise throughout all measurements at each site. The sound level meter was hand-held at 1 m from the ground, with the microphone directed to face the noise source- the block-making machine. In addition, the adjustment of the sound level meter was rechecked before each measurement. The duration of measurement was 5 minutes at each site. Measurements were carried out with different timing durations, from 20 to 25 minutes, due to the pretest and to check for measurements' accuracy. At each location, measurement was taken at the noise source (0 m away), then at 10 m, 20 m, 30 m, 40 m and finally at the closest residential structures. At each sampling site, readings were repeated three times, and the mean value was determined. After each measurement, the device was restarted and ready for the subsequent measurement.

Vibration level measurements were conducted on the machines of the selected 25-block industries. Before each measurement, the method and purpose of the measurement were explained to the workers and managers, who were permitted to observe the measurement process. The vibration level was measured using a digital vibration meter, model VM-6360, designed especially for easy on-site machinery vibration. It measures various parameters: displacement, velocity, acceleration, frequency, and rotation per meter (RPM). In this study, acceleration was the parameter used. The instrument consists of a piezoelectric accelerometer and has a wide frequency range (10 Hz-10 kHz) in acceleration mode, with a measuring range of 0.10-400.00 ms^{-2}. Since the value of acceleration is constantly changing, a single overall digit is often considered suggestive. The magnitude of the acceleration is usually expressed as the root-mean Square (RMS) value of rapidly changing acceleration. The accelerometer probe was placed in contact with the upper press mold of the machine before the cement-sand mix was loaded into the machine for molding, and measured acceleration was taken. With the accelerometer still in contact with the upper press mold, the acceleration was taken as the molding process began. The measurements in this manner constituted the vibration level of the block-making machine. Also, the accelerometer probe was placed in contact with the hand of the machine operator before the molding process began and at the point where he held onto the control level of the machine to end the molding process of a block. The measurements taken in this manner where the accelerometer was in contact with the operator's hand constitute the vibration level received by the operator's hand. This process was repeated in all the sites. The duration for taking these measurements varied between 5-7 minutes at each location.

The statistical package for social sciences (SPSS 20.0) was used to analyze the data. The analysis was done at 5% levels of significance in terms of individual tests (t-test) and overall tests (F-test) to check for the significance of the relationship between the variables. In addition, statistical parameters such as mean, standard deviation, skewness, minimum and maximum were determined.

Results

The summary of the noise level measurement results obtained at the different block molding industries is given in Table 1. The distance represented as noise source here implies directly in front of the block-making machine.

Table 1: Mean Noise Level with distance at the various block industries

Block Industries	At Noise Source 0 m dB(A)	10 m away dB(A)	20 m away dB(A)	30 m away dB(A)	40 m away dB(A)	Closest residential structure dB(A)
Omo Oluagba	100.20±1.00	81.17±0.86	71.07±1.18	64.73±0.59	62.63±0.45	71.10±0.53
Adeniyi	103.27±0.15	90.60±0.60	83.47±0.38	77.50±0.38	73.27±0.21	74.20±0.10
Bibire	101.07±1.15	78.83±1.25	61.83±0.25	56.77±0.40	55.07±0.42	51.13±0.76
Auto	103.40±0.10	92.70±0.20	89.30±0.10	80.40±0.10	76.87±0.15	66.83±0.15
Folson	101.00±0.10	78.83±0.25	74.37±0.38	69.23±0.15	64.20±0.10	73.63±0.21
Arekemase	101.90±0.10	85.50±0.26	78.20±0.10	79.57±0.15	72.80±0.10	72.23±0.15
Mofesade	103.67±0.15	88.80±0.10	75.23±0.15	68.70±0.10	70.93±0.15	62.90±0.10
KES-G	100.07±0.25	81.63±0.15	76.57±0.15	69.13±0.21	67.50±0.20	62.57±0.15
TSK	103.17±0.21	91.80±0.10	84.30±0.10	76.47±0.21	71.63±0.15	68.63±0.25
RBB	100.63±0.57	82.57±0.21	74.33±0.21	68.60±0.10	63.37±0.15	63.37±0.15
Divine Mercy	102.30±0.20	92.30±0.20	79.87±0.21	74.43±0.21	67.77±0.15	71.10±0.10
GST	101.63±0.21	88.50±0.10	73.07±0.15	62.47±0.15	57.37±0.15	49.97±0.15
ZAC	103.53±0.15	89.93±0.15	79.07±0.15	69.10±0.10	64.60±0.10	51.07±0.15
Forward Ever	100.60±0.10	79.10±0.10	72.57±0.25	67.50±0.20	60.80±0.70	65.53±0.15
Aranse Oluwa and Sons	102.10±0.20	87.57±0.21	79.57±0.15	71.93±0.15	69.00±0.10	63.27±0.21
Endurance	103.40±0.10	90.30±0.10	82.80±0.10	76.70±0.10	72.50±0.10	67.87±0.21
Rock of Ages	100.00±0.10	79.77±0.15	63.93±0.15	57.63±0.25	51.67±0.15	61.33±0.15
Teledase	101.67±0.15	86.43±0.15	78.20±0.10	75.57±0.15	68.73±0.06	64.43±0.15
Ibukun Olu	100.17±0.25	79.70±0.10	68.50±0.10	65.60±0.10	62.30±0.10	61.90±0.10
A.K.A Apa	101.60±0.10	88.93±0.15	76.60±0.10	69.70±0.10	64.47±0.15	57.53±0.15
Golgotha	101.13±0.21	81.83±0.25	77.43±0.25	70.13±0.15	67.47±0.15	60.00±0.20
Ona Ara	103.40±0.10	89.90±0.20	78.57±0.15	73.00±0.10	66.67±0.15	62.27±0.15
Adekunle & Sons	102.70±0.20	89.50±0.20	79.03±0.21	72.33±0.21	68.07±0.42	59.20±0.10
God is good	100.20±0.36	82.43±0.25	75.77±0.15	69.50±0.20	65.27±0.15	67.30±0.20
Durojaiye	102.53±0.15	81.77±0.15	76.30±0.10	68.60±0.20	62.70±0.10	60.77±0.31

The results in Table 1 showed that noise generated by these molding machines decreases with distance. The noise level at the source was the highest among the five different distances where measurements occurred. The average values of noise recorded were 101.81±0.10 dB(A), 85.62±0.26 dB(A), 76.40±0.21 dB(A), 70.21±0.19 dB(A), 65.91±0.19 dB(A) and 63.61±0.20 dB(A) at 0 m, 10 m, 20 m, 30 m, and 40 m, respectively.

While Table 2 presents a summary of the Noise Level measurements. Table 3 represents the results of the regression analysis.

Table 2: Summary of the Noise Level Measurements

Distances	Overall Means (N) dB(A)	Minimum dB(A)	Maximum dB(A)	Block Industry (Maximum)	Block Industry (Minimum)
At Noise Source	101.81	100	103.67	Mofesade	Rock of Ages
10 m away	85.62	78.83	92.7	Auto	Folson
20 m away	76.4	61.83	89.3	Auto	Bibire
30 m away	70.21	56.77	80.4	Auto	Bibire
40 m away	65.91	51.67	76.87	Auto	Rock of Ages
Closest residential structure	63.61	49.97	74.2	Adeniyi	GST

Table 3: Regression Model Using Noise Level as the Dependent Variable

	Coefficients	Standard Error	t Stat	P-value	F	Sig. (F)	Remark
Intercept	105.6233	13.34628	7.91407	0.00421	42.207	0.0074	Significant
Distance	-1.07044	0.164767	-6.4967	0.00741			Significant

The vibration level measurements of the block-making machine (Vm) measured in ms^{-2} are presented in Table 4 for the average, standard deviation (spread), minimum level measurement, maximum level measurement and skewness. The skewness is an indicator of the deviation of the variables from a normal distribution (which, in this case, implies compliance to standard vibration level) with an expected value of zero. The vibration level measurements on the arm (Vb) measured in ms^{-2} of the operators are presented in Figure 1.

Table 4: The Vibration Level Measurement of the Molding Machine (Acceleration ms^{-2})

Block Industries	Mean±*SD* (B.M)	Mean±*SD* (A.M)	Skewness (B.M)	Skewness (A.M)	Range (B.M)	Range (A.M)
Omo Oluagba	2.6±0.3	305.3±23.4	-0.59	-1.24	2.1-2.6	260.2-305.3
Adeniyi	4.6±0.3	304.1±43.1	-0.59	0.28	4.1-4.6	265.1-351.2
Bibire	0.9±0.1	332.0±15.6	0.0	0.01	0.9-1.1	332-363.1
Auto	6.6±0.1	296.2±2.4	0.0	0.61	6.5-6.7	296.2-301
Folson	3.9±0.2	262.1±6.2	1.29	1.44	3.9-4.3	250.4-262.1
Arekemase	6.3±0.2	362.6±11.8	-0.94	1.48	6.0-6.3	340.4-362.6
Mofesade	8.9±0.5	324.2±17.5	-0.33	-0.78	8.0-8.9	324.2-358.8
KES-G	3.1±0.2	252.6±8.5	0.0	-0.94	2.7-3.1	241.5-258.1
TSK	4.7±0.3	301.9±13.9	0.94	0.72	4.7-5.3	301.9-329.4
RBB	6.7±0.4	329.4±22.4	-1.6	1.61	6.1-6.8	323.9-365.1
Divine Mercy	5.5±5.1	273.4±280.1	0.42	1.56	4.8-5.5	268.7-298.2
GST	7.3±7.4	354.5±354.1	0.94	-0.17	7.1-7.7	339.3-368.1

Block Industries	Mean±*SD* (B.M)	Mean±*SD* (A.M)	Skewness (B.M)	Skewness (A.M)	Range (B.M)	Range (A.M)
ZAC	5.7±5.9	328.2±323.8	1.29	-0.77	5.7-6.1	297.1-346.2
Forward Ever	2.4±2.4	271.1±270.6	0.0	-0.19	2.2-2.6	258.3-282.4
Aranse Oluwa and Sons	3.8±3.5	336.8±346.0	0.0	-0.94	3.2-3.8	336.8-353.4
Endurance	3.7±3.6	256.5±359.6	-0.94	0.97	3.3-3.9	247.9-274.3
Rock of Ages	6.3±7.4	274.3±277.6	0.94	1.3	6.1-6.7	269.4-289.1
Teledase	7.1±7.3	345.7±323.8	0.59	0.4	7.1-7.6	303.7-345.7
Ibukun Olu	4.3±4.3	248.1±249.1	-0.59	0.19	4.0-4.5	226.5-272.6
A.K.A Apa	7.2±7.5	342.5±346.8	-0.59	1.51	7.2-7.7	338.8-359.2
Golgotha	4.6±4.7	331.2±334.4	0.94	0.86	4.6-4.9	320.2-351.7
Ona Ara	3.4±3.4	293.7±290.7	0.59	-1.48	3.2-3.7	281.8-296.5
Adekunle & Sons	6.5±6.3	348.7±353.7	0.0	1.48	6.1-6.5	348.7-361.2
God is good	5.4±5.5	314.5±310.7	0.94	-0.82	5.4-5.7	289.3-328.4
Durojaiye	6.3±6.6	326.9±333.6	0.94	1.73	6.3-6.9	326.8-347.1

S.D = standard deviation

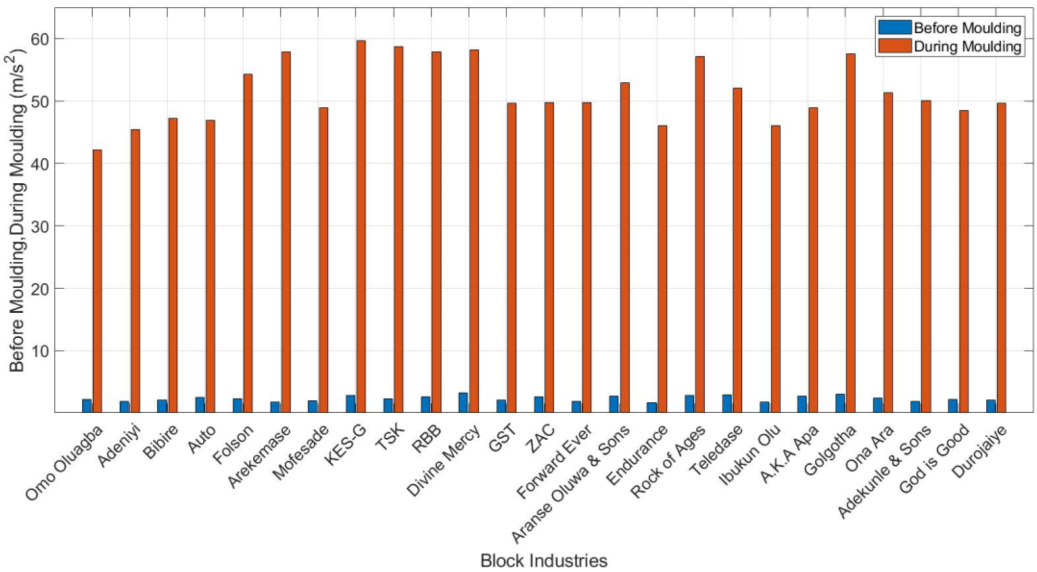

Figure 1. The Vibration Level on the arm of the operators of the molding machines

Discussion

Noise pollution from the block-molding industries has become worrisome due to their proximity to residential buildings. Even though the importance of block industries cannot be underestimated and the need for more block industries, it is, however, necessary to ensure that the nature of operation of these industries is not detrimental to the workers and local population. The present paper reports on the operation of block-molding industries in the city of Ibadan. Results (Table 1) emanated from the current investigation revealed that the level of noise measurements at the noise source in all the industries exceeded the given noise standard of 90 dBA by the Federal Environmental Protection Agency (FEPA) and Occupational Safety and Health Administration (OSHA). Similarly, a comparison of the present investigation result with the recommended HSE 2005 regulations of human tolerance to noise revealed that the measured noise level at sources and 10 m away exceeded the 85 dBA safe limit.

In contrast, for distances 20 m, 30 m, and 40 m away and at the closest residential structure, the noise level measurements for all the industries fall below the given noise standard. However, at a distance of 10 m, the noise level measurement for some industries exceeded the given noise standard, while some were close to the standard. From the present study, it can be deduced that as the distance from the noise source increases, the values of the noise level measurement decrease. This implies that the noise level measured at the source is higher than at farther distances. The results of the present investigation are consistent with the findings of Jibiri et al.[17]

The summary table (Table 2) confirms that all the block industries emit noise levels above the required standard at the noise source. It further ensures that the noise level falls slightly above the given noise level standard at distances 20 m, 30 m, and 40 m away and the closest residential structures. It also shows that Auto Block Industry emitted the highest noise level at 10 m, 20 m, 30 m, and 40 m away. In contrast, Mofesade Block Industry and Adeniyi Block Industry emitted the highest noise level at the noise source and closest residential structure, respectively. The results of the present investigation are in agreement with the findings of Ogunseye et al.[18] In their study, noise exposure levels of petty traders at some major roundabouts in Ibadan were measured, and the results revealed that the measured exposure levels were within the 90 dB(A) for 8 hours as recommended by the Occupational Safety and Health Administration.

The data from the present investigation were fitted, and the line of best fit generated a model of the form:

$$N_i = \beta_0 + \beta_1 D_i + \varepsilon_i \qquad (1)$$

Where N represents the noise level, D represents distance, $\beta_0 = 105.62$, $\beta_1 = -1.07$ and ε_i represents the unaccounted factors that might have affected the noise level measurement. The model represents the relationship between the noise level measurements and distance(s). The analysis was done at 5% levels of significance in terms of individual tests (t-test) and overall tests (F-test) to check for the significance of the relationship between the variables.

It can be seen from Table 3 that an increase of 7.04 percent in the distance of measurement away from the noise source reduces the noise level measurement in the twenty-five block industries. It is a reduction because of the negative sign of the distance coefficient. The model showed a significant relationship and effects between noise level and the distance at 5% significance by the F-test, indicated by its minimal probability value of 0.0074. That is, the overall p-value of the relationship between noise and distance for the model is 0.0074, which is less than 0.05; therefore, by the decision rule, the relationship is significant. Thus, it is confirmed that there is a significant relationship between the noise level measurement and distance from the noise source. The degree of relationship between the noise level measurements and distance(s) at 5% significance levels. The $R^2 = 0.933639$ (93.4%) implies that the distance in the regression equation explains 93 percent of the total variation in the Noise level measurement; $N = 105.6233 - 1.07044D$.

As can be observed from Figure 1, the values of the vibration level reaching the hand before the machine begins to mould approximately comply with the vibration level standard but greatly exceed it when the machine begins to mould. We, therefore, seek to confirm if there is a significant difference between the measurement values taken. We use the measurements of the machine's vibration level as a case study. The result is analysed by the decision rule, which determines its significance. Hypothesis:

H_0: There is no significant difference between before and during machine molding

H_1: There is a significant difference between before and during machine molding.

$\alpha = 5\% = 0.05$

Since the p-value is lesser than the level of significance, i.e. $3.13\times10^{-26} < 0.05$ (sig.α), the H_0 is therefore rejected, and it can be concluded that there is a significant difference in the mean vibration level value before and during molding. Hence, the test is significant. This implies that the levels of vibration measurement are different. Similarly, for other measurements, it is obvious that the test is significant and the values have significant differences. According to related research, hand-arm vibration exposures result in documented negative health effects like "white finger" when higher vibration energy is applied to the hands and fingers using powered hand tools or machines.[17]

Conclusions

The result of this study showed that the noise level generated by block industries decreases with an increase in distance and exceeds the occupational noise level standard at the noise source and 10 m away from the noise source. This implies that the workers in the block industries could be the principal victims of the possible adverse health effects associated with noise level exceedance and those that interact with the premises close to the machines while in operation. Furthermore, it can be established that the safe distance for a second party to set up a structure is 20 m and above. At these distances, there is a possible low health risk from the noise emitted by the block-making industries. The vibration levels obtained in this study exceeded the occupational vibration level standard. This indicates that the block-making machine operators in the block molding industries may be exposed to adverse health effects due to high vibration levels at their workplaces. It is therefore recommended that hearing protection gadgets be mandatory, and this should be enforced on workers in the block-making industries. Anti-vibration protection gloves should be adapted for the operator of the machine.

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