Evaluation and Modelling of Environmental Noise Pollution from a Palm Oil Processing Mill with a Maximum Noise Level of (110.64±0.69) dBA

Etinamabasiyaka Ekott[1], Kufre Abasi Essien[2]

[1, 2]Department of Physics, Faculty of Science, University of Uyo, Akwa Ibom State, Nigeria

Abstract: ***A palm oil processing mill noise has negative environmental impact. The distances at which its adverse effects shall cover have to be professionally determined. This work therefore presents evaluation and modelling of environmental noise pollution from a palm oil processing mill with a maximum noise level of (110.64±0.69) dBA. Measurements of noise levels with respect to distance, x from the mill were considered. The linear regression method was used in analysing the data. Environmental noise models were developed by using the relevant displayed parameters. The results obtained from the models developed in this work, $L_{(modelled)}$ were compared with the results obtained from the physical measurements, $L_{(measured)}$ and there was no significant difference between them. The distances, x_c in metres in which its adverse effects covered in the residential areas were $0 \leq x_c \leq 82$. The distances, x_s in metres at which it can be sited from the residential areas were $83 \leq x_s \leq \infty$; The results show that the equivalent continuous noise level, L_{eq} of the mill decreased as x increased. Finally, with the existence of x, the models developed in this work are recommended to be used as more reliable tools for environmental noise impact assessments.***

Keywords: Distances, evaluation, modeling, noise levels and palm oil processing mill

1. Introduction

Elevated noise levels of adequate exposure time can result in short-term or permanent hearing damage. This is generally related to those working in industrial plants or operating machinery but can also take place at discotheques or near to aircraft on the ground if the duration is long enough. However, measurable hearing loss from many industrial sounds involves daily exposure for a number of years. On the other hand, community noise intrusions like traffic noise can obstruct speech communication, interfere with sleep and relaxation and disturb the capacity to perform difficult tasks [1].

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 [2]. For this reason, it is often exigent to establish the benefits of dropping a specific noise. Noise does affect the inhabitants, humans, fauna, etc, 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. General noise sources are industry, neighbourhoods and traffic. The industrial noise is one of the most annoying sources of noise complaints [3]. Environmental noise is described by World Health Organisation (WHO) as community noise or residential noise or domestic noise [4]. The most important sources of community noise comprise 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. The major sources of indoor noises include aeration systems, home appliances; office machines, and neighbours [2].

The study of noise is highly imperative so as to create awareness on the impacts of noise on the environment for the betterment of our society. In this research, the evaluation of environmental noise levels as they vary with distances and the development of models for predicting and controlling environmental noise pollution from a palm oil processing mill with a maximum noise level of (110.64±0.69) dBA shall be carried out

2. Literature Survey

In 1993, a study carried out by Cornell University 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 [5], [6]. Noise has been connected to vital cardiovascular health risks. In 1999, the WHO drew a conclusion that the existing evidence shown predicted a weak relationship between hypertension and long term exposure to noise beyond 67 – 70 dBA [7]. 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 [8].

In the United States of America, the Environmental Protection Agency (EPA) identified noise as a hindrance since in the 1970s [9]. Then, the agency carried out a main study of noise and has continued to bring up to date its results. This means that the study of noise is a continuous phenomenon. As with all pollutants, noise demeans 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. This increase in noise can be attributed to the ever increasing number of people in the globe and the growing levels of economic affluence [10].

Fairly characteristic road levels of noise are adequate to reduce arterial blood flow and cause elevated blood pressures; in this situation it seems that a specific part of the populace is more vulnerable to vasoconstriction. This may occur because the noise bother leads to high adrenaline intensity to activate vasoconstriction (a reduction of the blood vessels) or separately through reactions from medical stress. Additional impacts of elevated levels of sound are high rate of vertigo fatigue, stomach ulcer and headaches [3]. Results of findings have shown that constant noise above 55 dBA causes serious annoyance and above 50 dBA moderate annoyance at home [11]. 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 [4]. In Britain, the current and advanced Ministry of Agriculture regulations established in January 2002 state 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 much greater than specified safe levels for around the residence. In fact, beyond 80 dB is near to the level at which ear protection should be used [9]. 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.

The British Columbia Work's Compensation Board (WCB) 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 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 gave the safe level around home to be 50 – 55 dB [12].

3. Methods/Approach

3.1 Physical measurements

Physical measurements of noise levels were made using the sound level meter, model WensnWS1361 with ½ inch Electret condenser microphone. This model has both A and C weightings and 0.1dB resolution with fast/slow response. It has a measuring range 30 to 130 dBA or 35 to 130 dBC. It is equipped with a built in calibration check (94.0 dB) and tripod moving. It has an accuracy of ± 1.5 dB. It has AC and DC outputs for frequency analyser level recorder, Fast Fourier Transform (FFT) analyser, graphic recorder and others. It also has electronic circuit and readout display and a weight of 308 g. The microphone senses the small air pressure variations related to sound and converts them into electrical forms. These signals are then passed to the electronic circuitry of the instrument for processing. The readout displays the processed sound levels in dB. The sound level meter picks the sound pressure level at one instance in a certain location. Measurements were taken by adjusting the sound level meter to A-weighting network in all the sampling locations. The sound level meter was calibrated. The manufacturer's manual gave the calibration procedure. During the noise level measurements, the microphone of the sound level meter was positioned at a distance of above 5 m from the palm oil processing mill at a height of 1.2 m above the ground and windshield was always used for accuracy. Slow response was used for comparatively stable noise measurement. For instance, work place noise level measurements were taken on slow response. Here, the response rate is the time period over which the instrument averages the sound level before displaying it on the readout. Fast response was used for fast varying noise. Measurement of workplace sound pressure was made in the uninterrupted noise field in the workplace, with the microphone located at the position normally occupied by the ear exposed to the highest value of exposure [13].

3.2 Noise level with distance measurements

In this case, the palm oil processing mill with a maximum noise level of (110.64±0.69) dBA was identified. Measurements of noise levels from it as they vary with distance were taken. All noise level measurements were carried out using the sound level meter, while distance measurements were made using a measuring tape. Lastly, L_{eqs} for them were evaluated.

3.3 Calculating the equivalent continuous noise level (L_{Aeq})

The L_{Aeq} is the steady noise level over a certain period of time that generates very similar quantity of A-weighted energy as the varying level over identical period. It is presented in equations (1-2) and it is measured in dBA.

$$L_{Aeq} = 10\log_{10}[\frac{1}{T}\int_0^T \frac{P(t)^2}{P_0{}^2}dt] \quad (1)$$

$$L_{Aeq} = 10\log_{10}(\frac{1}{T}\int_0^T 10^{0.1L_i}\,dt) \quad (2)$$

where, T= time period over which L_{Aeq} is determined, P(t) = the instantaneous A-weighted sound pressure, P_o = the reference sound pressures (20 μPa) and L_i = noise level in the ith sample.

Formula used for calculating the equivalent continuous noise level L_{eq} of a noise source, *N* at a particular distance, x is presented in equation (3) [1].

$$L_{eq} = 10\log_{10}\{\frac{1}{T}\{10^{0.1L_N}\Delta T_N + 10^{0.1L_B}\Delta T_B\}\} \quad (3)$$

The noise level of a noise source, L_N is presented in equation (4) [14], [1], [15].

$$L_N = 10\log_{10}(10^{0.1L_{TOTAL}} - 10^{0.1L_B}) \quad (4)$$

where, T=Time period over which L_{eq} is determined, ΔT_N=Time period over which noise level of a noise source is measured, ΔT_B =Time period over which background noise level is measured, L_N=Noise level of a noise source in dBA, L_B =Background noise level in dBA, L_{TOTAL} =Total noise level in dBA. and, T= 5 minutes, ΔT_N= 2 minutes, ΔT_B= 3 minutes.

Noise modeling

The data obtained were analysed and the linear regression method was applied. Hence, linear fitting models were developed for it by using the relevant displayed parameters. Finally, a general model for evaluating, controlling and predicting environmental noise pollution from a source of this type was developed. The results are presented in sections 3.

4. Results & Discussion

Analysis of noise levels and distance measurements from a palm oil processing mill with a maximum noise level of (110.64±0.69) dBA

The results (Table 1 and Fig. 1) show that the noise of the palm oil processing mill with a maximum noise level of (110.64±0.69) dBA is more disturbing at distances where the noise level at palm oil mill, palm oil noise level and L_{eq} are above the WHO tolerant level of 55 dBA for a non-work place. Within distances of 80 - 100 metres the noise levels are not evenly attenuated; this may be due to some noise barriers that were existed in the direction of the noise level measurements. It is shown that the background noise levels at distances 5 – 100 metres are below the WHO safety noise level of 55 dBA. This signifies that in the absence of the mill the area is conducive for living. Hence, a mill of this type should be sited at appropriate distances from the residential areas for the betterment of our environment. However, the workers should be advised to wear ear protector and the duration of exposure should be professionally controlled.

Model development for noise levels and distance measurements of a palm oil processing mill with a maximum noise level of (110.64±0.69) dBA

The results of the analysis of the noise levels of a palm oil processing mill with a maximum noise level of (110.64±0.69) dBA, L_M show that the noise levels of the palm oil processing mill, L_M and distance, x are strongly correlated with the coefficient of determination, R^2=0.99438. This gives a linear fitting model in dBA as presented in equation (5).

$$L_M = 110.63936 - 0.67253x \tag{5}$$

Introducing the error term, ϵ_M, equation (5) becomes

$$L_M = 110.63936 - 0.67253x + \epsilon_M \tag{6}$$

In equation (5), if $x = 0$, the noise level of the palm oil processing mill at source is:

$$L_M = 110.63936 \text{ dBA} \tag{7}$$

Equation (7) represents the intercept or the maximum noise level with a standard error of 0.69455 dBA. The model has a slope of –0.67253 $dBAm^{-1}$ with a standard error of 0.0116 $dBAm^{-1}$. Comparing the predicted noise levels of the palm oil processing mill, $L_{M(modelled)}$ with its measured noise levels, $L_{M(measured)}$ (Table 2 and Figures 2-4) indicate that there exist no significant difference between them. This implies that $L_{M(modelled)}$ and $L_{M(measured)}$ are strongly correlated. The coefficient of determination, R^2=0.994 in Fig. 4 also confirms that there is no significant difference between $L_{(measured)}$ and $L_{(modelled)}$. Hence, equation (5) or (6) can be used as a model for evaluating, predicting and controlling environmental noise pollution from a palm oil processing mill of this type.

The following conditions satisfy the model presented as equation (5):

(I) $0 \le x_c \le 82$; at $x_c = 82\ m$, $L_M = 55.49190$ dBA

(II) $83 \le x_s \le \infty$; at $x_s = 83\ m$, $L_M = 54.81937$ dBA

Condition (I) implies that the adverse effects of the noise from the palm oil processing mill cover distances from 0 m (point of its installation) to 82 m. This is because at a distance of 82 m from the palm oil processing mill, its noise level is 55.49190 dBA instead of the WHO tolerant level of 55 dBA for residential areas. The distance at which the adverse effects covered is denoted by x_c in metres. Condition (II) means that the palm oil processing mill should be operated or sited from the residential area at a distance of 83 m and above. This is because at the distance of 83 m, the noise level of the palm oil processing mill is 54.81937 dBA, which is less than the WHO recommended level of 55 dBA. Here, x_s is the distance it can be sited in metres (m).

Table 1: Noise levels and distance measurements from a palm oil processing mill with kernel cracking machine

Distance, x (m)	*Background noise level (dBA)*	*Noise level at palm oil mill (dBA)*	*Palm oil mill noise level (dBA)*	*Equivalent continuous noise level, L_{eq} (dBA)*
5	35.8	106.8	106.7999997	102.82060010
10	36.6	102.5	102.4999989	98.52060047
15	35.5	99.9	99.89999842	95.92060070
20	35.9	97.1	97.09999671	93.12060156
25	36.3	93.8	93.79999228	89.82060377
30	37.0	90.7	90.69998147	86.72060918
35	36.9	87.1	87.09995853	83.12062065
40	35.8	84.9	84.89994657	80.92062663
45	36.1	81.4	81.39987183	77.42066400
50	37.2	79.2	79.19972597	75.22073692
55	39.0	74.7	74.69883092	70.72118433
60	39.8	70.6	70.59638619	66.62240569
65	40.0	65.5	65.48774264	61.52671565
70	38.9	63.9	63.88624464	59.92746129
75	39.1	60.8	60.77053838	56.83525611
80	39.3	55.3	55.18951667	51.37480515
85	40.4	50.7	50.27451435	46.91866745
90	38.8	52.6	52.41507408	48.71019146
95	37.5	49.0	48.68111735	45.17167015
100	39.6	43.5	41.22776101	40.32574694

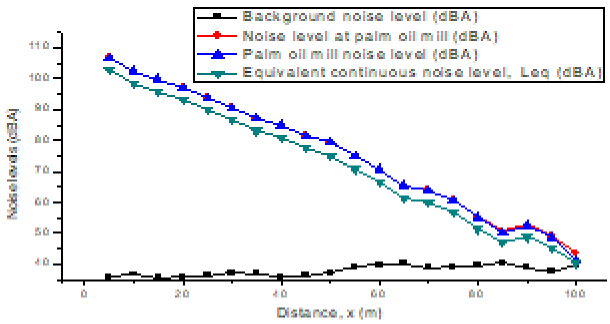

Figure 1: The palm oil processing mill noise levels against distance

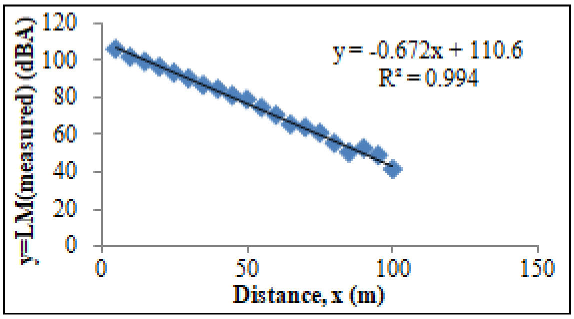

Figure 2: The characteristics of the palm oil processing mill measured noise level

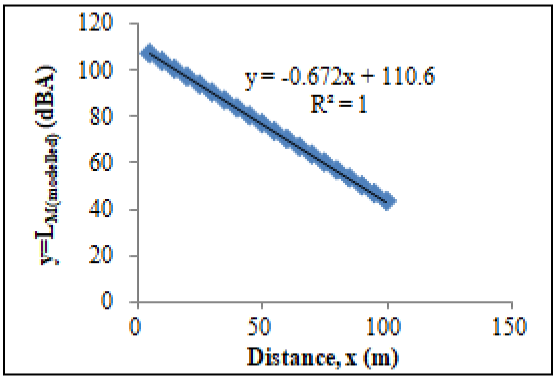

Figure 3: The characteristics of a palm oil mill modelled noise level

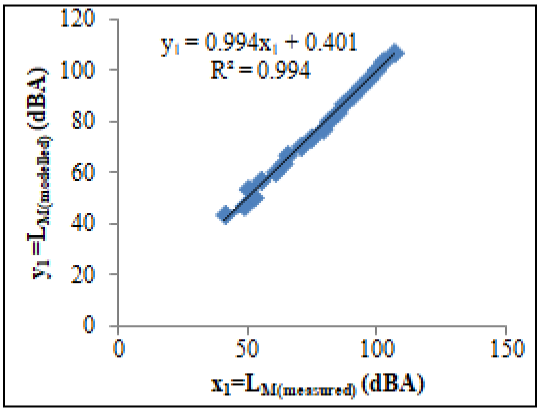

Figure 4: Comparison of modelled noise levels, $L_{M(modelled)}$ and measured noise levels, $L_{M(measured)}$ of the palm oil mill

Table 2: Comparison of modelled noise levels, $L_{M(modelled)}$ and measured noise levels, $L_{M(measured)}$ of a palm oil processing mill with a maximum noise level of (110.64±0.69) dBA

Distance, x (m)	*$L_{M(measured)}$ (dBA)*	*$L_{M(modelled)}$ (dBA)*	*$L_{M(difference)}$ (dBA)*
5	106.8000	107.2767	-0.4767
10	102.5000	103.9141	-1.4141
15	99.9000	100.5514	-0.6514
20	97.1000	97.1888	-0.0888
25	93.8000	93.8261	-0.0261
30	90.7000	90.4635	0.2365
35	87.1000	87.1008	-0.0009
40	84.8999	83.7382	1.1618
45	81.3999	80.3755	1.0244
50	79.1997	77.0129	2.1869
55	74.6988	73.6502	1.0486
60	70.5964	70.2876	0.3088
65	65.4877	66.9249	-1.4372
70	63.8862	63.5623	0.3240
75	60.7705	60.1996	0.5709
80	55.1895	56.8370	-1.6474
85	50.2745	53.4743	-3.1998
90	52.4151	50.1117	2.3034
95	48.6811	46.7490	1.9321
100	41.2278	43.3864	-2.1586

Development of a general model for evaluating, predicting and controlling environmental noise pollution

Generally, it is observed that all the models developed in this work are of the forms in equation (8) and equation (9).

$$L_N = -\theta x + \beta \quad (8)$$

$$R^2 = \alpha \quad (9)$$

where, θ is the slope representing the attenuation coefficient of the noise from the palm oil processing mill and it is measured in $dBAm^{-1}$. β is the intercept or the maximum noise level signifying the noise level at source (i.e at $x = 0$) in dBA. x is the distance in metres (m) and α is the coefficient of determination. Substituting equation (8) into equation (3), gives equation (10).

$$L_{eq} = 10\log_{10}\{\tfrac{1}{T}\{10^{0.1(\beta-\theta x)}\Delta T_N + 10^{0.1L_B}\Delta T_B\}\} \quad (10)$$

Equation (10) therefore shows that when θ and β for the palm oil processing mill are known, L_{eq} of the noise source can be determined at any distance, x with the consideration of the background noise level, L_B at that point. Hence, with the introduction of the distance of measurement, x equation (10) can be used as a more scientific and reliable general model for evaluating, predicting and controlling environmental noise pollution from a palm oil processing mill of this type. Therefore, this model can be applied in environmental noise impact assessment. L_{eq} is the equivalent continuous noise level. It is measured in dBA.

5. Conclusion

It is concluded from the findings that the equivalent continuous noise level (L_{eq}) of the mill decreases as the distance from it increases**.** The distances, x_c in metres in which its adverse effects covered in the residential areas are $0 \le x_c \le 82$. The corresponding distances, x_s in metres at which it can be sited from the residential areas are $83 \le x_s \le \infty$. All the models developed in this work can be used in evaluating, predicting and controlling environmental noise pollution from a palm oil processing mill of this kind. They require less cost, less manpower and less time than physical measurements. They can be used by the manufacturer of the noise generating equipments to reduce their maximum noise levels. They can be used to predict the exact distance at which adverse effects of noise from this palm oil processing mill can cover. Hence, the models are recommended to be used as reliable tools for environmental noise impact assessment as the results show insignificant difference between the measured noise levels, $L_{(measured)}$ and the modelled noise levels, $L_{(modelled)}$.

6. Future Scope

More researches should be done on other sources of noise for the betterment of our environment.

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Author Profile

Dr. Etinamabasiyaka Ekott comes from Akwa Ibom State, Nigeria. He is a holder of B. Sc. Physics, second class Honours (Upper Division) in 2008 M.Sc. in Electronics/Communication Physics in 2012 both from the University of Uyo, Akwa Ibom State, Nigeria. He obtained a Ph.D degree in Engineering Physics (Acoustics) from the University of Calabar, Cross River State, Nigeria. He is a lecturer at the University of Uyo, Akwa Ibom State, Nigeria. He has several publications in reputable journals.

Rev KufreAbasi Essien is a Physicist, Copywriter and Publicist. He obtained his B.Sc. from the University of Uyo and M.Sc. from the University of Nigeria. Rev KufreAbasi Essien is married to Nancy, and has three children.