

Measurement and Evaluation of Noise Levels Produced by a Palm Produce Processing Facility with a Maximum Noise Level of 114.69 DBA

*Etinamabasiyaka E. Ekott, David M. Okon, Kufre Offiong

Department of Physics, University of Uyo, Nigeria.

*Corresponding Author

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ABSTRACT

This research work presents measurement and evaluation of noise levels produced by a palm produce processing facility with a maximum noise level of 114.69 dBA. The noise level measurements were made using the sound level meter, model WensnWS1361. Distances, x , from 10 m to 150 m from the Processing Facility were maintained using a measuring tape. The background noise levels, L_B were taken when the facility was not put to use while, the average noise levels, L_{AV} were taken when the palm produce processing facility was in full operation. The noise levels of the facility, L_{PP} was then calculated from L_{AV} and L_B . The data obtained were compared with the WHO safety standards. The results revealed that the adverse effects of the facility covered beyond a distance of 110 m from it. This is because at $x=110$ m, the sound levels of the facility, $L_{PP}=55.90$ dBA; instead of the WHO safety standard of 55 dBA for a non-workplace. The average sound levels and the facility noise levels are approximately the same up to a distance of about 140 m away from the facility. This simply means that they have almost the same frequency up to the 140 m. This study recommends that a minimum setback distance of 120 m should be maintained between a palm produce processing facility of this kind and residential or other noise-sensitive areas to minimize adverse noise impacts. It also recommends that workers operating within 60 m of the facility should wear appropriate hearing protection devices, such as earmuffs or earplugs, because noise levels exceed the recommended occupational limit of 85 dBA.

Keywords: Measurement and evaluation, noise levels, palm produce processing facility

INTRODUCTION

Noise is generally defined as unwanted or excessive sound that can interfere with normal activities, reduce comfort, and adversely affect human health and the environment. Industrial activities, including palm produce processing, are among the major sources of environmental noise in many developing countries. Palm produce processing facilities utilize machines such as digesters, screw presses, threshers, sterilizers, and diesel-powered generators, all of which generate significant levels of noise during operation [1]. In Nigeria, the increasing establishment of small- and medium-scale palm produce processing facilities has contributed to rising environmental noise pollution, particularly in rural communities where residential buildings are often located close to processing sites. Continuous exposure to excessive noise can result in hearing impairment, sleep disturbance, reduced work efficiency, communication difficulties, stress, hypertension, and other cardiovascular disorders [1], [2]. Population explosion and increasing human activities are attributed to noise pollution in many urban areas and cities of the world. Environmental noise is often referred to as unwanted sound [3].

Noise pollution being a by-product of modern development in technology is a major constraint on the quality of life in urban settlements. In most urban areas, noise pollution is a result of unplanned settlements and is perceived as the least containment among all environmental pollutants [4]. One important effect of

noise is to make a person's speech less easy to hear. The human brain automatically compensates the production of speech for background noise in a process called the Lombard effect in which it becomes louder with more distinct syllables. Noise is a growing health threat, and if left unchecked, could result to hazardous conditions [5]. The growth in noise pollution is unsustainable because it involves direct, as well as cumulative, adverse health effects. Researchers have shown that constant noise above 55 dBA causes serious annoyance and above 50 dBA moderate annoyance at home [6]. 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. World Health Organization, [7] recommended community noise levels of less than 30 dBA in bedrooms, during the night for a sleep of good quality and less than 35 dB(A) in classrooms for good teaching and learning conditions. 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 [8]. Increasing noise pollution in the world has affected human beings, animals, plants and even inert objects like buildings and bridges; noise has been used to signify the hazard of sound which consequences in the modern day development is immeasurable [9]. Noise exposure is not a new phenomenon as records show that even in medieval times, carriages and horseback riding were banned during the night in some cities in Europe, in order to prevent sleep disturbance [10]. Hearing losses are the most common effects of noise pollution. An investigation shows that markets with very high noise levels have high risk of adverse health effects on humans if the duration of exposure is not properly managed [11]. The survival and healthy existence of man depend largely on the enabling environment where he resides, as disruption in the environment may lead to dysfunction in his health status [12]. Noise pollution, being a product of urbanization and industrialization, is now recognized as major problem in urban areas with many adverse effects. This is attributable to the substantial growth in the number of vehicles, expansion of road network, industrialization and urbanization. Traffic noise on the other hand is probably the most rigorous and pervasive type of noise pollution [13]. Traffic noise has become a serious problem in recent times because of inadequate urban planning of the city on the past. This alarming increase in the volume of traffic is actually inversely related to the degradation of the environment [14]. A recent study to evaluate the health risk levels associated with types of residential noise indicated that people in the areas were exposed to many sources of noise, where cars and lorries top the list. It was maintained that planting of trees along streets, roads and highways can be adopted to reduce the levels of health risk associated with residential noise [15]. Generally, heavier traffic volumes, higher speeds and greater numbers of trucks increase the loudness of traffic noise. Traffic noise is not usually a serious problem for people who live more than 160 m from heavily travelled free- ways [16].

Blasts and other intense or explosive sound can rupture the ear drum or cause immediate damage to the structures of the middle and inner ear, while, hearing loss due to prolonged noise exposure is generally associated with destruction of the hair cells of the inner ear [17]. Noise pollution in Nigeria cites is relatively high when compared to recommended levels by World Health Organization [18], [19]. It is a general observation that indoor noise is perceived as more "low –frequency-like" than the same noise heard out of doors [20]. Once typical highway speeds are reached, the predominant noise from light trucks and cars is from the time/road interaction. Heavy trucks produce a high volume of noise from all three sources even at low speeds [16]. High noise level was discovered to cause stress and high blood pressure which is the leading cause of health problem [21]. Critical analysis of community noise bothers revealed that airport area with a mean noise level of 90.35 dBA, even though it was located very far away from the residential areas had 29% of the respondents bothered by the noise of aircrafts [22]. Fairly typical road way noise levels are sufficient to constrict arterial blood flow and lead to elevated blood pressure; in this case, it appears that a certain fraction of the population is more susceptible to vasoconstriction. This may result because annoyance from the sound causes elevated adrenaline levels trigger a narrowing of the blood vessels (Vasoconstriction), or independently through medical stress reaction. Other effects of high noise levels are increased frequency of headaches, fatigue, stomach ulcers and vertigo. For instance, children from noisy areas have been found to have heightened sympathetic arousal indicated by increased levels of stress related hormones, likewise, those working in noisy office environments have also been found to be less cognitively motivated, and to have higher stress levels [23]. Studies have shown that neighbourhood noise (consisting of noise from neighbouring apartments, as well as noise within one's own apartment or home) can cause significant irritation and noise stress within people, due to the great deal of time people spend within their residences.

This can result in an increased risk of depression and psychological disorders, migraines, and even emotional stress. In an environmental noise impact assessment, people were exposed to many sources of noise like aircrafts, tricycles/motor cycles, cars, churches, children, animals, workshops/factories, lorries, compact disk sellers, traders and ships/engine boats, power generators and night clubs [24].

Findings involving the evaluation of noise levels and distances from a business centre with a maximum noise level of (83.35 ± 0.91) dBA showed that its noise affected the area beyond a distance of 50 m. The findings revealed that at the distance of 50 m, the total noise level was 56.3 dBA instead of the WHO tolerant noise level of 55 dBA for a non-work place. Hence, it was recommended that this kind of business centre should be sited beyond a distance of 50 m from the residential areas [25]. In the work place, noise pollution is generally a problem once the noise level is greater than 55 dB (A). Studies show that approximately 35 to 40% of workers in office settings find noise levels from 55 to 60 dB (A) to be extremely irritating. Evaluation and modeling of environmental noise pollution from a palm oil processing mill with a maximum noise level of (110.64 ± 0.69) shows that the adverse effect of noise from the mill covered distances up to 82 dBA from the mill [26]. In fact, the noise standard in Germany for mentally stressful tasks is set at 55 dB (A). This study therefore involves measurement and Evaluation of Noise Levels Produced by a Palm Produce Processing Facility with a maximum noise level of 114.69 dBA.

MATERIALS AND METHOD

Sound Level Meter

All the sound level measurements were made using the sound level meter (SLM), model WensnWS1361 with $\frac{1}{2}$ 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. Also, 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.

Noise Level with Distance Measurements

A palm produce processing facility with a maximum noise level of 114.69 dBA was investigated. Three measurements were obtained at each sampling distance, with each measurement lasting 2 minutes. The measurements were conducted while the facility was operating under normal production conditions, with the generator, milling machine, and grinding equipment operating simultaneously. Data collection was carried out between 9:00 a.m. and 2:00 p.m. in July 2026 under dry weather conditions, with no rainfall and relatively low wind speeds, in order to minimize the influence of meteorological conditions on the measured noise levels.

The background noise level, L_B , was measured when the processing facility was not in operation, whereas the average sound level, L_{AV} , was measured while the palm produce processing facility was operating at full capacity under normal production conditions. The facility-generated noise level, L_{PP} , was subsequently determined from L_B and L_{AV} using Equation (1). The sampling distances were measured with a measuring tape and ranged from $x=10$ m to $x=150$ m from the facility. Measurements were taken along the direction in which relatively high noise intensities were observed. The selected measurement path was largely free of tall grasses, crops, and trees in order to minimize the effects of vegetation on sound propagation and absorption. The facility-generated noise levels were subsequently compared with the World Health Organization (WHO) safety value of 55 dBA for residential areas.

Calculating the noise level of the palm produce processing facility (L_{PP}) in dBA

Equation (1) was used to calculate the noise level of the palm produce processing facility (L_{PP}): [26], [27], [24]:

$$L_{PP} = 10 \log_{10} [10^{0.1L_{AV}} - 10^{0.1L_B}] \quad (1)$$

Where,

L_{AV} = Average Noise Level in dBA

L_B = Background Noise Level in dBA

L_{PP} = Calculated noise level attributable to the palm produce processing facility (dBA).

Worked example

From Table 1, at $x=10$ m, $L_B=35.9$ dBA and $L_{AV} = 105.7$ dBA

Using equation (1), we get:

$$L_{PP} = 10 \log_{10} [10^{0.1L_{AV}} - 10^{0.1L_B}]$$

$$L_{PP} = 10 \log_{10} [10^{0.1 \times 105.7} - 10^{0.1 \times 35.9}]$$

$$L_{PP} = 10 \log_{10} [10^{10.57} - 10^{3.59}]$$

$$L_{PP} = 10 \log_{10} [37,153,522,910 - 3890]$$

$$L_{PP} = 10 \log_{10} [37,153,522,910 - 3890]$$

$$L_{PP} = 10 \log_{10} [37,153,519,020]$$

$$L_{PP} = 10 \times 10.57$$

$$L_{PP} = 105.7 \text{ dBA}$$

RESULTS AND DISCUSSION

Results

The results of the noise levels with distances of the palm produce processing facility are presented on Tables 1 and Figures 1- 4.

Table 1: Noise Levels and distances

x (m)	L_B (dBA)	L_{AV} (dBA)	L_{PP} (dBA)
10	35.9	105.7	105.70
20	37.3	102.6	102.60
30	36.8	99.4	99.40
40	38.5	94.9	94.90

50	39.1	90.1	90.10
60	37.4	85.6	85.60
70	39.0	81.3	81.30
80	38.8	76.2	76.20
90	39.9	76.9	76.90
100	40.0	67.6	67.60
110	39.8	55.9	55.90
120	38.9	50.8	50.80
130	37.5	46.1	46.09
140	38.7	41.4	41.38
150	38.6	39.9	39.88

x= Distance in m

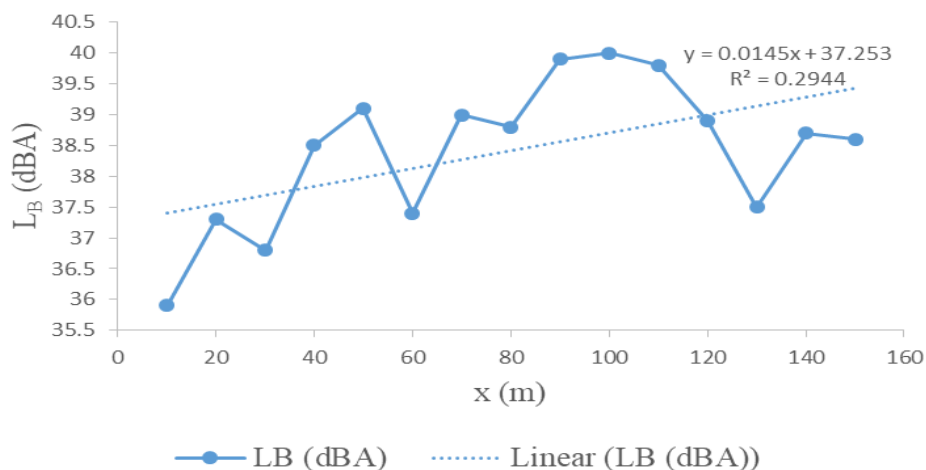


Figure 1: A graph of L_B against x

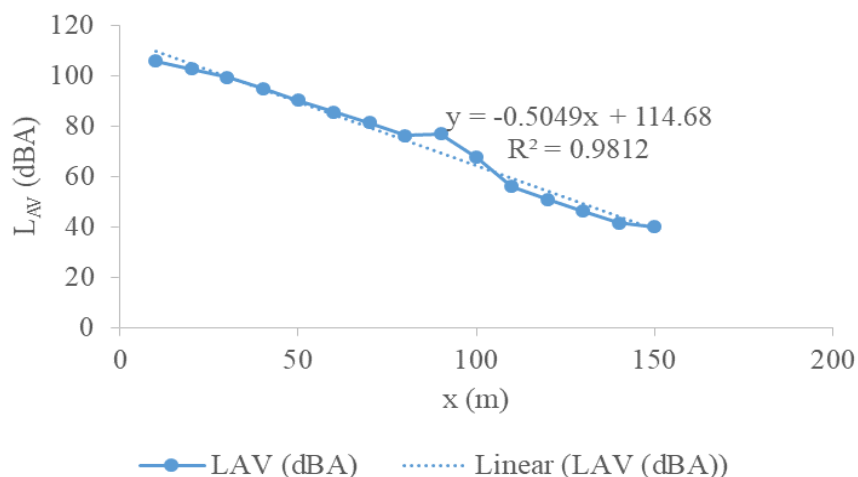


Figure 2: A graph of L_{AV} against x

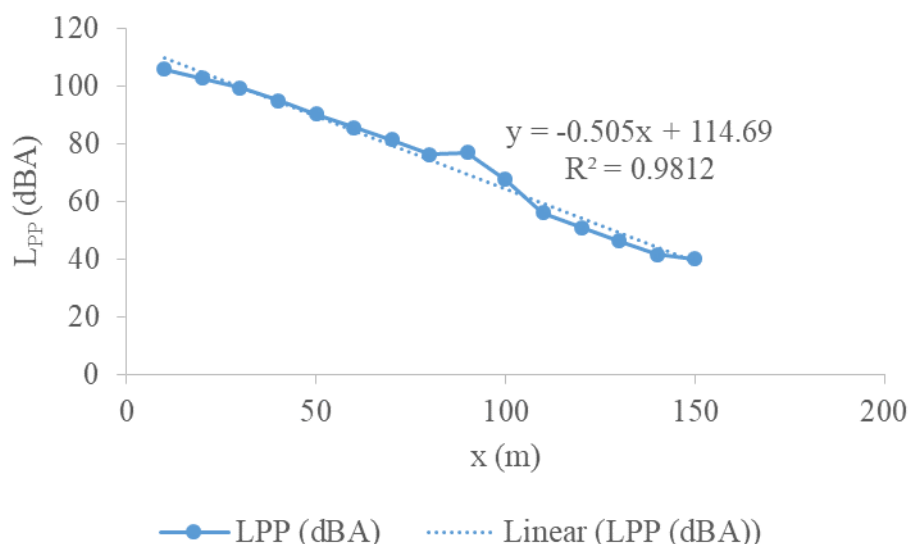


Figure 3: A graph of L_{PP} against x

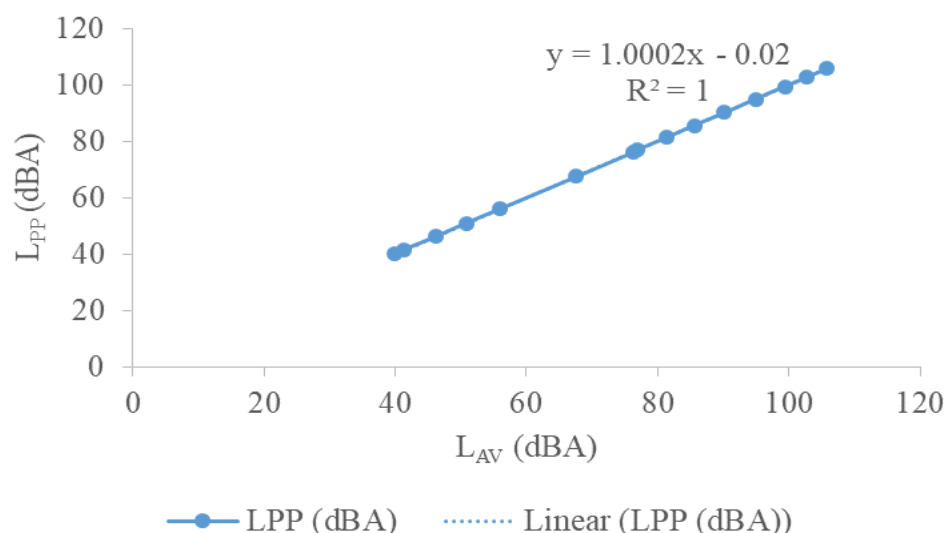


Figure 4: A graph of L_{PP} against L_{AV}

DISCUSSION

The results presented in Table 1 and Figures 1–4 show the variation of background noise level (L_B), average measured noise level (L_{AV}), and calculated palm produce processing facility noise level (L_{PP}) with distance from the processing facility. The background noise level ranged from 35.9 to 40.0 dBA across the measurement locations. These relatively low values indicate that the surrounding acoustic environment was comparatively quiet during the background measurements. All recorded background noise levels were below the 55 dBA environmental reference value adopted for comparison in this study.

During the operation of the palm produce processing facility, the highest average measured noise level (L_{AV}) of 105.7 dBA was recorded at 10 m from the facility. The corresponding calculated facility noise level (L_{PP}), determined from the measured average noise and background noise using the facility-noise calculation equation, was 105.70 dBA. The calculated facility noise generally decreased as the distance from the processing facility increased. The L_{PP} values were 102.60, 99.40, 94.90, 90.10, 85.60, 81.30 and 76.20 dBA at 20, 30, 40, 50, 60, 70 and 80 m, respectively. A slight increase from 76.20 dBA at 80 m to 76.90 dBA at 90 m was observed. Thereafter, the calculated facility noise decreased to 67.60 dBA at 100 m, 55.90 dBA at 110 m, 50.80 dBA at 120 m, 46.09 dBA at 130 m, 41.38 dBA at 140 m and 39.88 dBA at 150 m.

The overall decrease in L_{PP} with increasing distance demonstrates the attenuation of sound as it propagates away from the processing facility. The dominant mechanism is expected to be geometric spreading, which causes sound energy to decrease with increasing propagation distance. However, atmospheric absorption, ground interaction, vegetation, reflections from surrounding structures and other site-specific environmental conditions may also influence the observed propagation pattern. The slight increase in L_{PP} at 90 m indicates that the attenuation was not perfectly uniform at every measurement location. Such local fluctuations may result from reflections, ground effects, atmospheric conditions, vegetation, or variations in the operating conditions of the noise-producing equipment.

A comparison of the background noise with the calculated facility noise further demonstrates the contribution of the processing operation to the surrounding acoustic environment. At 10 m, the background noise was 35.9 dBA, whereas the calculated facility noise was 105.70 dBA. This substantial difference indicates that the processing operation was the dominant contributor to the measured acoustic environment at the shorter distance. As the distance increased, the calculated facility noise progressively approached the background noise level. At 150 m, L_{PP} was 39.88 dBA compared with a background noise level of 38.6 dBA. The relatively small difference between these values indicates that the calculated contribution of the processing facility had become comparatively small at this distance.

For environmental assessment, the calculated facility noise levels were compared with the selected 55 dBA environmental reference value. The L_{PP} values remained above 55 dBA from 10 m to 110 m, with a value of 55.90 dBA recorded at 110 m. At 120 m, L_{PP} decreased to 50.80 dBA and remained below 55 dBA at 130, 140 and 150 m. Therefore, under the operating and environmental conditions prevailing during the measurements, the calculated noise contribution of the palm produce processing facility fell below the selected 55 dBA reference value at approximately 120 m from the source. This suggests that increasing the separation distance between the processing facility and nearby noise-sensitive locations can substantially reduce the facility's contribution to the surrounding acoustic environment.

The present result may differ from the value reported in [26] because of differences in the characteristics and operating conditions of the investigated facilities. Factors such as facility production capacity, machine types, and number of machines operating simultaneously, equipment condition, production load and duration of operation can influence the resulting noise levels. In addition, environmental factors such as topography, ground characteristics, vegetation and the presence of natural or artificial barriers may modify sound propagation. Consequently, differences in reported setback distances between studies do not necessarily indicate inconsistency but may reflect differences in source characteristics and measurement environments.

Figure 4 presents the relationship between the calculated facility noise level (L_{PP}) and the average measured noise level (L_{AV}). The close correspondence between the two quantities across the measurement locations indicates that the calculated facility contribution followed the measured operational noise pattern closely. Both parameters generally decreased with increasing distance from the processing facility, further demonstrating the attenuation of the facility's noise contribution with increasing separation from the source.

Overall, the results demonstrate that the calculated noise contribution of the palm produce processing facility was highest close to the source and generally decreased with increasing distance. The calculated facility noise remained above the selected 55 dBA environmental reference value up to 110 m but decreased to 50.80 dBA at 120 m. Accordingly, approximately 120 m may be considered a study-specific setback distance for reducing the calculated facility noise contribution below the selected environmental reference value under the operating and environmental conditions investigated.

CONCLUSION

Based on the measurements obtained under the operating conditions of the palm produce processing facility, noise levels were assessed at distances ranging from 10 m to 150 m from the source. The calculated facility noise level (L_{PP}) generally decreased with increasing distance, from 105.70 dBA at 10 m to 39.88 dBA at

150 m, although a slight increase was observed at 90 m compared with the value recorded at 80 m. The calculated facility noise remained above the 55 dBA environmental reference value up to 110 m, where a value of 55.90 dBA was obtained, but decreased to 50.80 dBA at 120 m. Based on these results, a setback distance of approximately 120 m is suggested to reduce the calculated contribution of the processing facility to below the selected 55 dBA environmental reference value under the operating and measurement conditions of the study. The findings indicate that the processing facility made a substantial contribution to the surrounding acoustic environment, particularly at locations closer to the source.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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