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Assessment and Evaluation of Noise Pollution Levels in Selected Sawmill Factories in Port Harcourt, Nigeria

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ABSTRACT: A study of noise characteristics in some selected sawmill factories in Port Harcourt has been carried out. The study involves physical measurement of the noise levels using digital sound level meter and a social survey was conducted using questionnaire. Mean noise values of 92.49±1.91dB, 92.44±3.41dB and 92.0dB±9.55dB were measured at Rumuosi sawmill, Mile 3 sawmill and Mile 1 sawmill factories respectively. Maximum noise levels exceeded Federal Ministry of Environment (FMEnv) exposure limit 82% of the time at Rumuosi sawmill, 71% of the time at Mile 3 sawmill and 41% of the time at Mile 1 sawmill Mile 1. Thus, there is high noise pollution levels in the studied sawmill factories that may have negative impact on the workers and residents of the vicinity of the factories. Computed average noise level, Equivalent continuous energy level, noise pollution levels and exceedance factors indicate that the noise pollution levels of the three sawmill factories are very high. It is concluded that a risk of excess noise exposure exists among sawmill workers due to the very high noise levels found in this study. Also, those living in the vicinity of the sawmill factories are particularly at high risk of excess noise exposure. Proper regulation should be put in place by both State and Local Governments and sawmill factories should be located in designated non-residential area.

Key words: Sawmill Factories, Noise Pollution Levels, Exceedance Factor.

I. INTRODUCTION

Noise is one of the most common occupational health hazards. In many industrial and manufacturing environments, as well as in farms, cafeterias, permanent hearing loss is the main health concern. The primary objective of any environmental noise assessment or policy is to protect people from the adverse effects of noise in the environment. Excessive noise has the ability to cause nuisance, including sleep deprivation, stress and increased blood pressure, as well as other physical, physiological and psychological effects (Toronto Public Health, 2000).

The environment inside most sawmills is particularly hazardous from a noise exposure standpoint, simply due to the nature of the work being done (cutting and sawing with the associated machineries) and the volume of lumber that passes through on a daily and weekly basis (Niels, 1999). A series of detailed studies have been conducted with respect to noise exposure and occupational noise induced hearing loss in sawmill factories (Niels, 1999; Vaishali *et al,* 2011; Agbalagba *et al,* 2013).

Noise levels generated by sawmill machines in operation have been reported by Vaishali *et al,* (2011) to vary from 80dB (A) up to 120dB (A). It is well recognized in industry that noise is a serious problem with sawing machines (Vaishali *et al,* 2011). Not only can the cutting and sawing noise be extremely high, there is also the additional factor that, even when idling, sawing machines can produce noise levels up to 95dB (A). As stated by Ebemiro and Abumere (1999) exposure to noise exceeding 85 dBA has proved to cause temporary or permanent hearing loss. Also, workplace noise of 90 dBA or above has been proven to reduce working efficiency and increase the liability to make mistakes and thus resulting in decrease in productivity through increment in loss of man-hours.

Even though many sawmill workers in developing countries claim to be undisturbed by workplace noise and its associated health hazards, there are many effects of which they may be unaware. A recent study by the University of British Columbia of over 27000 sawmills workers found correlations between working in a noisy environment and heart disease (Vaishali *et al,* 2011).

Noise may be a factor contributing to the strain of civilized life which is attributed to various physical and mental ailments. The world Health organization (WHO) estimates that 250 million people have a hearing loss and two third of these people lived in developing countries (Vaishali *et al*, 2011). The quest for industrialization and economic emancipation has made many developing countries in the world to embrace small and medium scale industries without proper assessment and investigation of industrial noise pollution impacts.

The aim of this study is to assess and quantitatively evaluate the noise levels of sawmill factories in Port Harcourt in order to ascertain the degree of impacts on sawmill workers and the public. There is inadequate research works on noise levels in sawmill factories in developing urban city of Port Harcourt. It is on this basis that this noise survey work was carried out on some sawmill factories in Port Harcourt order to quantitatively assess and evaluate the noise levels experienced in the daily operation of sawmill workers and the residents within and outside the mills.

The scientific analysis and social survey of noise pollution level in sawmill factories and the socio-economic implication make this research study unique and relevant to decision makers and planners. The result of this study would inform decision makers as well as sawmill operators of the noise levels sawmill employees are exposed to and the health implication in order to make relevant regulations that would protect human health. It would also give background information on the type of precautions and controls sawmill operators and decision makers would take to protect workers and public health in order to increase productivity.

MATERIALS AND METHODS

A total of Three (3) sawmill factories were selected and monitored during field survey. An hourly data recording interval were carried out for Ten (10) hours to cover daily operation of sawmill workers. Monitoring locations are as shown in the Table 1.

Table 1: Monitoring Location.

S/N	Location	Coordinate
1	Rumuosi sawmill	E6°56′ 36.34″ N4°52′ 50.706″
2	Mile 1sawmill,	E6°59′ 17.320″ N4°47′ 22.056″
3	Mile 3 sawmill	E6°59′ 36.198″ N4°48′ 23.820″

Smart Sensor (Model AR854) and TES (Model 1352H) sound level meters/data loggers were used to measure noise levels at each location. Measuring range is 30~130dBA. Accuracy is ±1.5dB; resolution is 0.1dB; the frequency range is 20Hz to 8.5 KHz. The noise meters were calibrated to assure that they were within calibration tolerances.

Measured values of noise levels at each monitoring location were obtained and recorded using above programmable noise meters, which give instant real time readings. Measurement instruments were placed between 3 meters high above the ground in accordance with NSW (2000) noise measurement procedure. Average of 10 sets of reading were taken at each location (making up 30 sets of readings). Based on these, the average noise levels of L_{av}, L_{eq}, and L_{max} with standard deviation were determined individually for each monitoring location.

The exercise was carried out in compliance with statutory requirements. Results were compared with Noise Standards and Control Regulations -2009. S. I. No. 35, WHO standard and OSHA Occupational Noise Regulations - 1910.95.

Statistical and mathematical analysis tools were applied in the course of these studies, to compute standard deviations, average noise levels, Equivalent continuous equal energy level (L_{eq}); Noise Pollution Levels (NPL), The Excedance Factor (EF) and Noise Exposure Level. Also computed were noise dose and Time weighted average noise level.

III. SOCIAL SURVEY

Social survey was also conducted in the case study sawmill factories as part of the overall assessment, using questionnaires. Questionnaire was designed to cover age, job identification, staff noise senility rate and condition, non-staff perception and business of non-staff within the vicinity of the factories location. A total of 84 questionnaires were served and 81 were completed and returned, which form the basic data analysis and discussion in this research.

IV. RESULTS AND DISCUSSION

Results of measured noise levels obtained during field monitoring of the selected sawmill factories in Port Harcourt are presented in Tables 1-6 and Fig. 1-6.

Variations of noise levels measured at study locations are shown in Fig. 1. The average noise level, Lav, equivalent continuous equal energy level, Leq, and noise pollution levels, NPL for each study location are shown in Table 2.

Computed OSHA percentage nose dose and Time Weighted Average for each location are shown in Table 3. While Table 4 shows the estimated time a Worker is to be exposed to noise levels that exceeded OSHA noise criteria.

Based on the results shown in Table 2, the noise limit exceedance factors for each study location were computed and rated as shown in Table 5 and Fig. 2. Measured noise levels at each location were ranked and plotted against the percentage of time equal or exceeded the 90dB exposure limit as shown in Fig. 4 to 6. Percentage of time exceeded or equal to L_{10}, L_{50}, L_{90} for each location were determined from Fig. 4 to 6 as shown in Table 6.

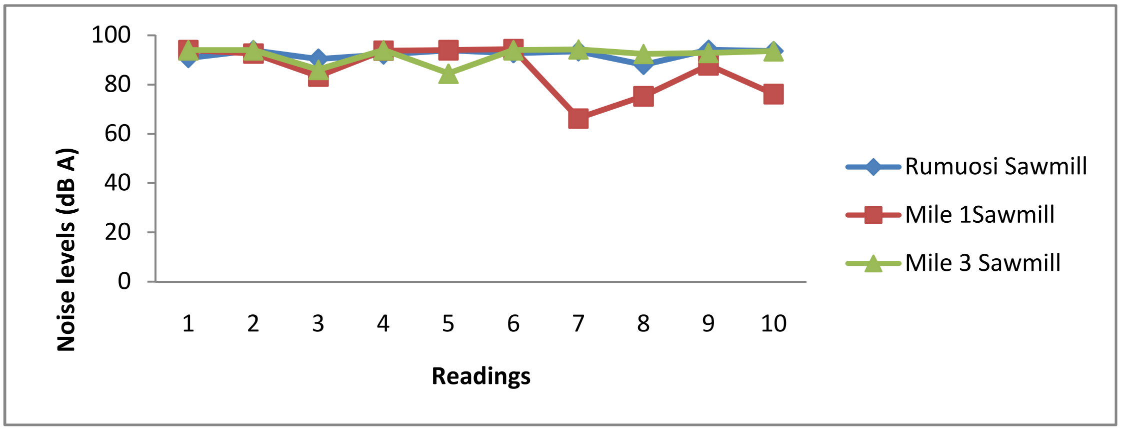

Fig. 1. Variations of Noise levels at study.

Table 2: Computed Average noise level, Lav, Equivalent Continuous Equal Energy level, Leq, and Noise Pollution Level for study locations.

	Lav (dB A)	**Leq (dB A)**	**NPL (dB A)**	**Standard deviation**
Rumuosi sawmill	92.49	97.88	97.9	±1.91
Mile 1 sawmill	92.0	96.24	99.5	±9.55
Mile 3 sawmill	92.44	98.02	100.4	±3.41

Table 3: Computed Noise Dose and Time Weighted Average

	OSHA DOSE (%)	**TWA (dB A)**	**Comment**
Rumuosi sawmill	177.5	94.1	Significant Risk
Mile 1 sawmill	122.1	91.4	Significant Risk
Mile 3 sawmill	177.4	94.1	Significant Risk

Table 4: Workers expected time exposure for noise levels.

Rumuosi sawmill (dB A)	T_n (hour)		Mile 3 sawmill (dB A)	T_n (hour)		Mile I sawmill (dB A)	T_n (hour)
90.4	7.6		92.4	5.7		92.5	5.7
90.7	7.3		92.8	5.4		93.7	4.8
92.2	5.9		93.5	4.9		93.9	4.7
92.7	5.5		93.9	4.7		93.9	4.7
93.5	4.9		94	4.6		94.3	4.4
93.6	4.9		94.1	4.5			
93.9	4.7		94.2	4.5			
93.9	4.7		94.4	4.3			
94.1	4.5						

Table 5: Computed Noise Limit Exceedance Factors for study locations.

	Lav	**Leq**	**NPL**	**Noise rating**	**Level of Risk**
Rumuosi sawmill	1.03	1.087	1.09	Very high	Significant
Mile 1sawmill	0.99	1.069	1.11	Very high	Significant
Mile 3 sawmill	1.03	1.089	1.12	Very high	Significant

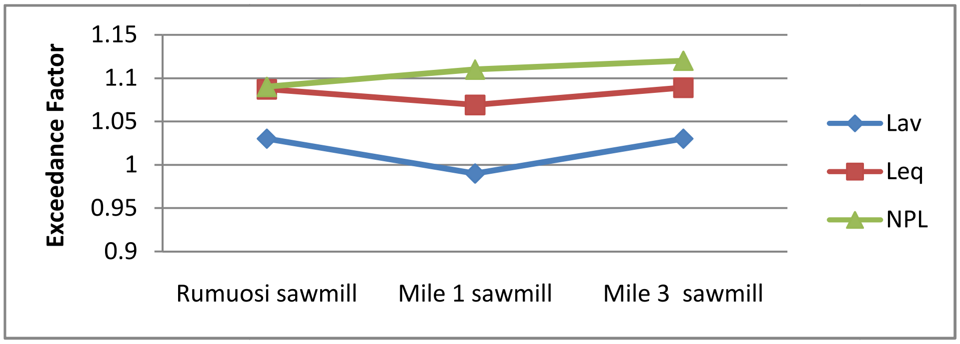

Fig. 2. Noise Level Exceedance Factors for each sawmill factory.

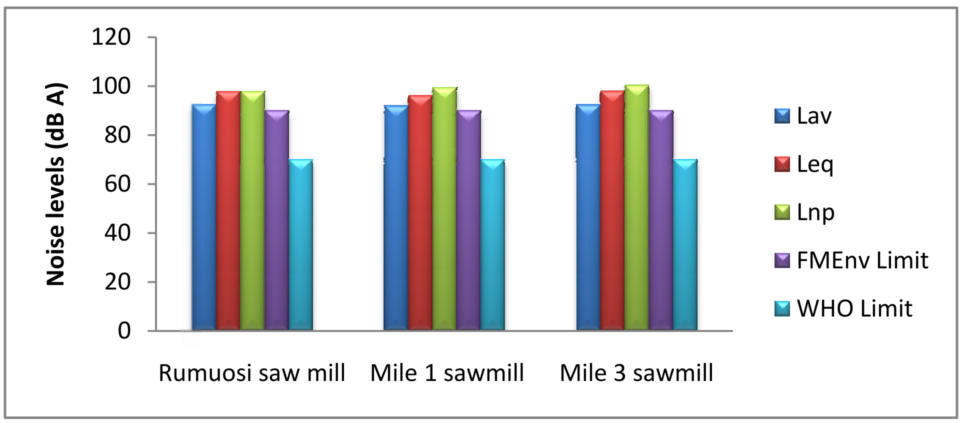

Fig. 3. Computed Average noise level, Lav, Equivalent Continuous Equal Energy level, Leq, and Noise Pollution Level for study locations in comparison with FMEnv and WHO limits.

Table 6: Percentage of time exceeded or equal to L_{10}, L_{50}, L_{90} for each location.

	L10 (dB)	L50 (dB)	L90 (dB)
Rumuosi sawmill	95.40	93.20	91.00
Mile 1 sawmill	97.20	95.20	93.20
Mile 3 sawmill	95.60	94.30	90.04

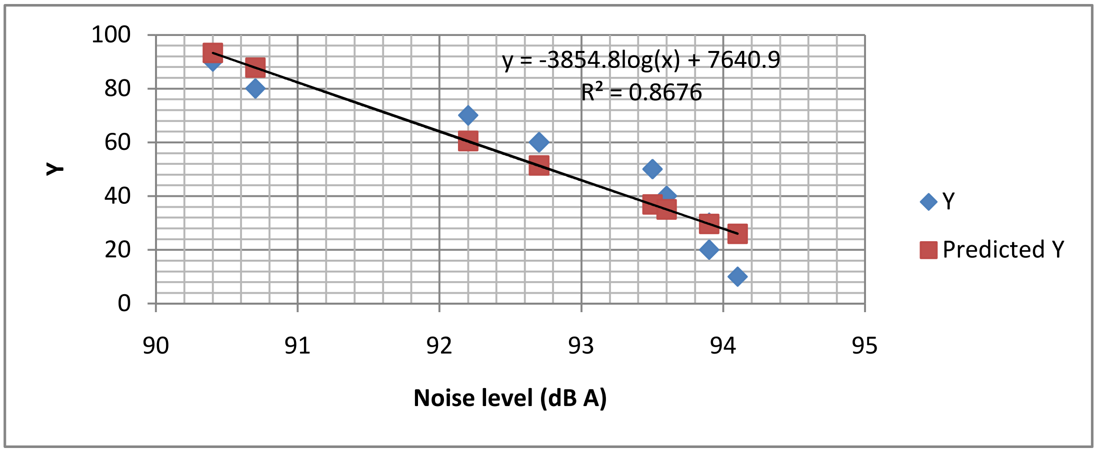

Fig. 4. Noise levels against percentage of time equal to or exceeded at Rumuosi sawmill.

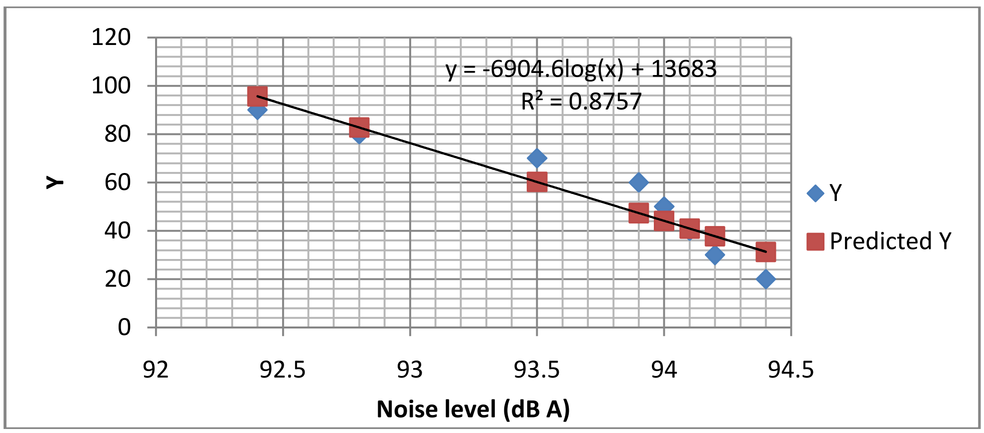

Fig. 5. Noise levels against percentage of time equal or exceeded at Mile 3 sawmill.

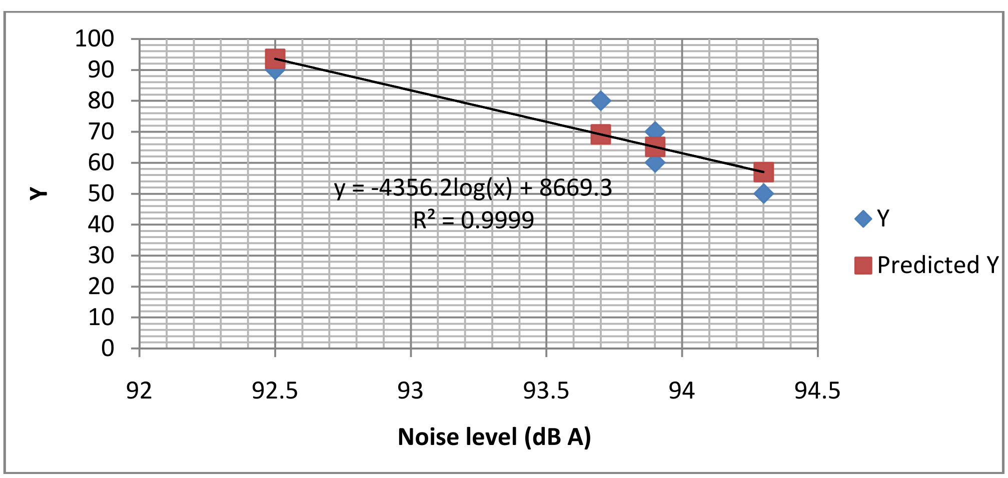

Fig. 6. Noise levels against percentage of time equal or exceeded at Mile 1 sawmill.

DISCUSSION

Results of noise levels measured during monitoring exercise showed that noise levels at Rumuosi sawmill ranged in values from 88.0dB to 94.1dB with mean deviation of 92.49±1.91dB. Measured noise levels at Mile 3 sawmill ranged from 84.4dB to 94.2dB with mean standard deviation of 92.44±3.41 dB; also, field measurement show that noise levels at Mile 1 sawmill ranged in values from 66.2dB to 94.3dB with mean deviation of 92.0±9.55dB.

The three sawmill factories have maximum noise levels of 94.1dB, 94.2dB and 94.3dB respectively. These values exceed FMEnv exposure limit 82% of the time at Rumuosi sawmill, 71% of time at Mile 3 sawmill and 41% of time at Mile 1 sawmill; and exceeded WHO standard 100% of the time. This indicates that there may be significant risk of Noise induced hearing loss for personnel working in this area.

Computed equivalent continuous equal energy level, $L_{eq\ showed}$ that Rumuosi sawmill had Leq of 97.88dB, Mile 3 sawmill has Leq of 96.24dB; while Mile 1 sawmill has Leq of 98.02dB. Also, computed noise pollution levels, NPL, for each study locations showed that Rumuosi sawmill has NPL of 97.9 dB; Mile 3 sawmill has NPL of 100.4dB; while Mile 1 sawmill has NPL of 99.5dB.

Computed Noise Limit Exceedance Factors based on L_{eq} values indicated that Rumuosi sawmill had exceedance factor of 1.087; Mile 3 sawmill has exceedance factor of 1.089; while Mile 1 sawmill had exceedance factor of 1.069. These are classified as Very High on a rating scale (CPCB, 2006). This indicated that the sawmill workers are exposed to high noise pollution and, thus may be at risk of accelerated presbycousis process or noise induced hearing impairment with age.

The overall result of data analysis revealed that noise levels in the three sawmill factories were far above the FMEnv recommended maximum permissible limit for an industrial environment. This result is similar to that reported by Agbalagba *el al,* (2013). This noise levels may cause hearing impairment to employees of these Sawmills especially the machine operators, it may also cause psychological effect on the people living or doing business around the factories areas. These were observed during the oral interviews conducted among the staff of the factories and residents as well as those doing business in the study areas.

A. Questionnaire Response Analysis

The first area of interest examined the issue of age bracket of the sawmill workers and the average working hours per day. Among many effects of noise pollution is that of accelerated decrease of hearing sensitivity with age or impairment of hearing acuity with age a process called presbycousis (Mackenzie and David, 2008).

The Presbycousis process appeared from the age of 30 years onward and becomes noticeable after the age of 40 years (Mackenzie and David, 2008). For the three sawmill factories in this study, the age distribution when respondents joined the services of the Sawmills is as follow: under 25 years is 22.3%, 25 – 30 years is 51.8%, 31 – 35 years is 18.6%, and 36 years and above is 7.3% of the total respondents respectively. This result on age distribution of respondents clearly shows that about 74.1% of the Sawmills workers are 30 years or less and, thus could be experiencing the effect of presbycousis process due high noise exposure.

The second area of interest examined the duration workers spent on the job in relation to noise exposure. 63.6% of the respondents have served between 1and 5 years; while 36.4% have served from 6years and above. 100% of respondents say they work in the factories for more than 8 hours in a day with no shift. The majority of the sawmill workers may therefore be exposed to high noise levels and thus may be at risk of hearing impairment or presbycousis process.

The third area of interest examined workers noise sensitivity rate and safety conditions as well as hearing status. In considering the noise from sawmill machines, 91% say it is very noisy, and 9% says it is extremely noisy. On the use of hearing protecting device, 100% respondents say “No” (do not use hearing protecting device).

Responds on the hearing status of the workers in the three sawmill factories showed that none of the workers have gone for ear checkup as many of them confessed that they have not heard of such checkup previously. This result shows that there is increasing level of hearing loss by the workers; however, they are not aware of this damaging health effect.

The fourth area of interest examined the noise sensitivity rate and tolerance level of non-workers doing business within the vicinity of the sawmill factories. 45.4% of respondents says they have lived and do business there for less than 1 year, 27.3% says they have lived and do business there between 2 and 5 years, while 27.3% says they have lived and do business within the vicinity of the factories for 6years and above. Concerning their feelings about the noise level emanating from the factories, 19.3% respondents says it is manageable, 56.6% responses says it is annoying, 15.8% describes it as very annoying, 8.3% says it is extremely annoying while no respondent says it is quiet. 72.7% respondents says the noise level at home (indoor) is very disturbing, 17.7% says it is less disturbing while 9.6% are indifferent about the degree of the noise experienced at home. 38.9% of respondents say they have partial hearing, while 61.1% cannot tell.

This result shows that residents in the vicinities of these factories are disturbed by the level of noise emanating from the sawmill factories.

The fifth area of interest examined the perception and views of neighboring residents and those doing business within the vicinity of the sawmill factories on the impact of noise on their health, factory location and mitigation measures. 63.6% of respondents says the noise has impacted them negatively, 13.6% says it has impacted them positively, while 22.8% was indifferent about it. Next is the opinions of residents on the locations of the factories, 64.8% supported the relocation of the sawmill factories to non-resident areas, 23.8% supported that the factories should remain in the present locations, 12.8% says factory noise should be reduced, while none supported the siting of more factories. The result indicates that the respondents are sensitive to noise pollution from the factories while those doing business consider the positive impacts on their trading activities and thus overlooked the noise pollution effects. However, the mitigation measure of noise reduction techniques is developed.

The overall questionnaire response results showed that a large number of the respondents are sensitive to the noise pollution impact, especially the non-staff residing in the neighborhood of the sawmill factories. Some respondents (mostly operator of machines in the factories) have already developed hearing difficulties of varying degrees. This was evident in the noise tolerance levels and sensitivity rates by workers of the factories and residents of the area as shown in Fig. 7 and 8. Result indicated that the respondents were sensitive to the noise pollution from sawmill factories, but were forced to continue their business in the area because of economic consideration.

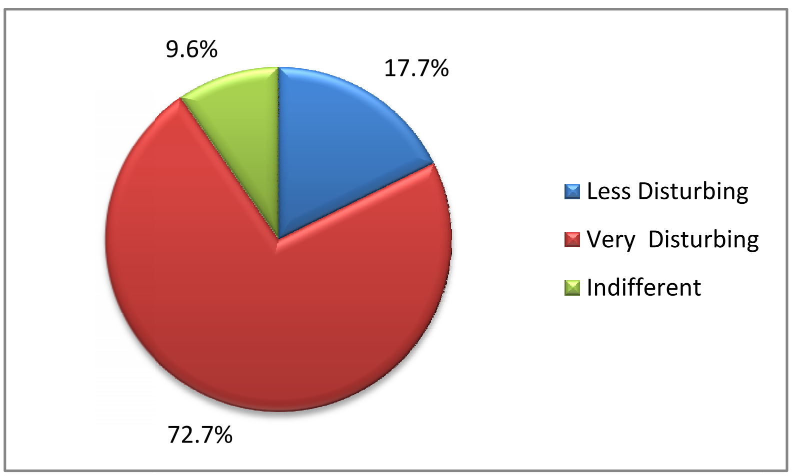

Fig. 7. Noise tolerance Levels of respondents.

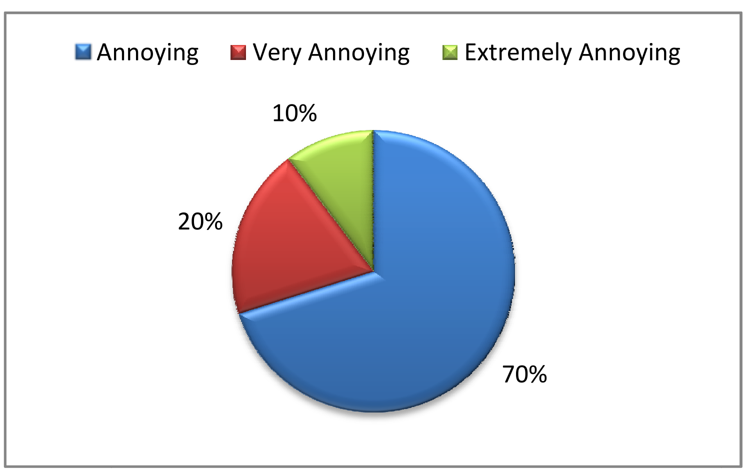

Fig. 8. Noise Sensitivity Rate of respondents.

CONCLUSION

A study of Noise characteristics of selected sawmill factories in Port Harcourt has been carried out. Based on results of field measurement, data analysis and social survey, the following conclusions can be drawn:
The field survey and analysis noise data revealed that the sawmill factories there were high noise pollution level in the studied sawmill factories that may have negative impact on health workers and residents of the vicinity of the factories. Computed average noise level, Equivalent continuous energy level, noise pollution levels and exceedance factors indicated high noise pollution level in the sawmill factories. This may cause noise-induced hearing impairment to workers and some psychological effects like susceptibility to irritation, and sleeping disturbance and social discomfort among residents living in close to these factories. Based on a conservative analysis, a risk of excess noise exposure could exist even when wearing required hearing protection due to very high noise levels found in planning operations in sawmills.
A risk of excess noise exposure exists among sawmill workers due to the very high noise levels found in this study. This may cause noise-induced hearing impairment among workers. Also, those living in the vicinity of the sawmill factories are particularly at high risk of excess noise exposure that may result in some psychological effect like susceptibility to annoyance, Speech Interference, sleep disturbance and social discomfort among residents living close to these factories. Proper regulation should be put in place by both State and Local Governments and sawmill factories should be located in designated non-residential area.

RECOMMENDATION

All sawmills workers should be well protected against the high noise level generated by the machines in the factories. Increasing awareness and training programmes for staff and residents of the areas on noise safety and other pollution impacts should be carried out regularly. A regular Medical Assessment/Test should be conducted on sawmill workers for early signs of presbycousis. Sawmill factories should be sited in industrial or isolated areas to avoid noise problem associated with mixed (domestic/industrial) environment. Efforts should be made by factory owner/ operators to replace worn out machine parts and do away with obsolete machines which are the major contributors to the high noise level in these areas. Regular noise auditing of the factories should be conducted to ascertain their compliance to FMEnv guidelines on noise generation. Government agencies responsible for the enforcement of laws or guidelines on noise should monitor Sawmills for compliance.

Sawmill factories management required action may include:
(i) Reduce the noise at source wherever possible.
(ii) Provide workers with training about hearing damage and protection.
(iii) Provide suitable hearing protection, which must be worn.
(iv) Carry out regular monitoring of the noise levels to ensure they have not increased.
The research acknowledges the following challenges which may slow down the implementation of the above recommendation as follows.
(i) Reducing noise exposure in the sawmill factories is difficult as appropriate technologies are not available.
(ii) Noise reduction is expensive as guarding and sound proofing materials are not affordable by small scale business men in developing countries.
(iii) Hearing protection may not be very effective as it is often not used properly and workers may find it uncomfortable.
(iv) There is no proper enforcement of industrial noise control regulation.

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