

RESEARCH ARTICLE

Acoustics

Determination of noise level and acoustic analysis of toys for children in Sri Lanka market

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Abstract: This study was conducted to determine the existing noise levels and perform acoustic analysis on different toys in the Sri Lankan market. The study was carried out using international references, and the noise level descriptors LpAeq, LpCpeak, and LpAFmax were recorded during measurement. A total of 205 toys were selected, and 1986 measurements were taken for analysis. The study reveals that 59 (28.8%) of the 205 toys in different categories had noise levels that exceeded two parameters, and 35 (17.1%) exceeded one parameter, considering the LpAeq, LpCpeak, and LpAFmax parameter values as described in BS EN 71-1:2011+A3:2014 Safety of toys. Measurements indicate that cap firing, wind, and squeeze toys have higher noise levels than international standards (reference values for cap firing: 125 dB, squeeze and cap firing: 110 dB). The study clearly indicates that when measuring noise levels in the frequency range compared to our normal reference hearing range (150 Hz to 5 kHz), it may affect the hearing levels. The study demonstrates the necessity for awareness, warning signs, and enforcing toy acoustic standards and regulations to improve the situation in Sri Lanka.

Keywords: Noise level, Sri Lanka market, toys noise, toys for children.

INTRODUCTION

Many toys produce noise, and children playing with toys also produce noise. Children are always learning something while playing with toys. Toys play an important role in the mental and physical development of children. They contribute to child development, and play

is an essential part of growing up. It helps children to improve certain skills and abilities during their childhood. However, toys must be safe for children to play with. The sounds generated by electronic and mechanical toys should not lead to damage to children's hearing. The maximum impulse and continuous sound levels emitted by toys should be within safe limits.

Most importantly, a child cannot verbally express or identify a hearing loss until at least the age of six (Axelsson, 1996). Exposing children to loud, noisy toys regularly or to one-time explosive toys can cause Noise Induced Hearing Loss (NIHL) in children's hearing. The unsafe incidents that can happen when playing with noisy toys and the effect of noisy toys on children's hearing is a major issue. There are many different kinds of toys all around the world. They can be categorized by considering various factors such as mechanism, size, age limit, and intended play. Toys are identified as one of the sources that can cause NIHL in children (Levey *et al.*, 2012). This is very dangerous because unlike teens and adults, children don't even realize that their hearing has been damaged. Even if they realize it, children under six years old cannot verbally communicate it (Axelsson, 1996). Even though there are safety standards like ISO, EN, and ASTM regarding the sound pressure levels of toys, there are still toys that exceed the recommended sound pressure levels. Also, as of 2021, there are still countries that do not have rules and regulations regarding appropriate sound pressure levels of toys.

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There are several studies related to the assessment of different toys around the world. One study was conducted by Yaremchuk *et al.* (1997) who tested 25 toys purchased from a national toy store in the USA in order to check the risk of noise-induced hearing loss in accordance with the Occupational Safety and Health Act (OSHA). The study showed that 13 toys exceeded the OSHA permissible noise level. In 2008, Bittel *et al.*, tested the noise levels of 24 toys in the USA and compared them to the recommended noise levels in the American Society for Testing and Materials International (ASTM International) noise standard in 2003 (Bittel *et al.*, 2008). The noise levels observed in this study revealed that many toys exceeded the recommended levels, which may cause noise-induced hearing loss in children. McLaren *et al.* (2013) evaluated 28 toys that were imported to New Zealand according to the ISO standard, and they showed that 21% of these toys did not meet the acoustic requirements in the ISO standard (AS/NZS ISO 8124.1:2010). Hawks (1998) measured the sound levels emitted by 22 toys that were intended to be used by children aged six months to 5+ years from different distances. From the results of this study, they suggest that the noise emitted by these toys carries a potential risk of high-frequency hearing loss for school-aged children. Sleifer *et al.* (2013) analysed the sound pressure levels emitted by 48 non-certified children's toys available at popular retail stores in Brazil and compared them to Brazilian standards. The authors concluded that the majority of these toys emitted higher sound levels than the recommended values.

The European Commission is considering implementing acoustical requirements in the toys directive. As of March 2001, Standard EN 71-1:1998 divided toys into five main categories. To the best of the authors' knowledge, no systematic measurements have been carried out in Sri Lanka to determine the degree of noise level in toys. In 1995, at the World Health Assembly, it was estimated that there were 120 million people with hearing difficulties worldwide. It has been shown that men and women are equally at risk of noise-induced hearing impairment (Smith, 1998). The importance of high-frequency audibility in the speech and language development of children with hearing loss has been discussed by Stetmachowicz *et al.* (2004).

The effects of noise can have various impacts based on daily activities and have been discussed in many research papers. Most studies have focused on industrial, transportation, and community noise, but there are few research papers regarding noise produced by toys.

In Sri Lanka, all kinds of toys are available in the market, with no indication of their sound emission levels. Neither the sound emission limit of the toy nor

the permissible distance from the child's ear is not mentioned. Additionally, there is no consideration for protecting children's ears from the noise emitted by toys. The sounds may be continuous, impulsive, or a combination of both in character. Sri Lanka has two noise control regulations related to the environment; however, they do not extend to toys.

MATERIALS AND METHODS

All samples were collected from existing toy shops located in various centres, open markets including individual vendors, and popular retail stores.

The selected toys were evaluated using the following references: ISO 8124-1:2018 Safety of toys - Part 1: Safety aspects related to mechanical and physical properties, and BS EN 71-1:2011+A3:2014 Safety of toys - Mechanical and physical properties. The tested toys were measured for A-weighted equivalent sound pressure level, L_{pAeq} , C-weighted peak sound pressure level, L_{pCpeak} , and A-weighted maximum sound pressure level, L_{pAFmax} . The two internationally standardized weighting networks in common use are the "A" and "C," which have been built to correspond to the frequency response of the human ear for different sound levels.

The measurements were taken according to the toy category using a B & K type 2270 handheld analyser, and the measured data were recorded. Different microphone positions were used for different toy categories. For a selected microphone position in each toy category, noise level readings were taken three times and recorded. Additionally, for each tested toy, the markings or warnings indicated on the packaging of toys were recorded. To ensure proper performance on battery-operated toys, new batteries were used. Each toy was operated as intended for about 15 seconds to measure sound pressure levels, except for cap-firing, wind toys, and pull-along or push toys. Cap-firing and wind toys were operated only once to measure sound pressure levels, while pull-along or push toys were operated at a selected distance to measure sound pressure levels. The following toy categories were selected for testing: table top or floor, hand held, squeeze, percussion, wind, rattles, pull-along or push, and cap firing. A total of 205 toys were tested, and 1986 tests were performed and analysed for the selected toys.

Noise levels were measured using a noise level analyser, Bruel & Kjaer (B & K) Type 2270 (class-1). The noise level meter was calibrated before and after taking the measurements using the noise level calibrator, B & K Type 4231, which is traceable to the primary standard maintained at Brüel & Kjær, The Calibration Laboratory, Denmark.

All noise level data were saved during measurement, and the data were analysed offline by the enhanced sound analysis software, Bruel & Kjaer BZ 7202, which conforms to the International Electrotechnical Commission (IEC) specific standard.

RESULTS AND DISCUSSION

Noise levels analysed with parameters

The results in Table 1 show that 59 (28.8%) of the tested toys' noise levels exceeded two parameters, and 35 (17.1%) of the toys exceeded one parameter out of 205 toys. In total, 94 (45.9%) items exceeded the prescribed

noise levels. However, when considering the category of the toys, two parameters were exceeded by all wind toys (13 units), and 9 cap firing toys also exceeded two parameters. Additionally, 36 (63.2%) of squeeze toys exceeded two noise level parameters. Among the table top toys, 67 (94.4%) did not exceed the recommended noise level. Similarly, 9 (81.8%) of the hand-held toys and 5 (100%) of the pull-along or push toys did not exceed the prescribed levels as per the international standard. In the selected toy categories, tabletop or floor, percussion, rattles, and pull-along or push toys were roughly providing better results compared to other toys. However, cap firing, wind-up, and squeeze toys gave higher noise levels compared to the international standard. The summarized results are given in the following Table 1.

Table 1: Summary of analysed measurements

Toys category	Number of tested items	Number of tests	Two parameters exceeded	One parameter exceeded	Not exceeded
Table top or floor	71	984	0	4 (5.6 %)	67 (94.4 %)
Hand held	11	180	1 (9.1 %)	1 (9.1 %)	9 (81.8 %)
Squeeze	57	172	36 (63.2 %)	17 (29.8 %)	4 (7 %)
Percussion	7	111	0	5 (71.4 %)	2 (28.6 %)
Wind	13	195	13 (100 %)	0	0
Rattles	32	99	0	8 (25 %)	24 (75 %)
Pull along or push	5	50	0	0	5 (100 %)
Cap firing	9	195	9 (100 %)	0	0
Total	205	1986	59 (28.8 %)	35 (17.1 %)	111 (54.1 %)

Noise level distribution variations relative to international standard (BS EN 71) limits

The variation of wind toy sound levels (LAeq and LpCpeak) with the number of measurements is shown in Figure 1(a). A total of 195 measurements were taken and analyzed for wind toys. However, 189 noise level measurements exceeded the international standard noise level with an LAeq value of 85 dB(A), and 153 noise level measurements exceeded the recommended noise level with an LpCpeak value of 110 dB(A), as shown in Figure 1(a). Similarly, the sound level variation of squeeze toys with the number of measurements is shown in Figure 1(b). A total of 172 measurements were taken and analysed for squeeze toys. However, 149 noise level measurements exceeded the recommended noise level LAeq values, and 82 noise level measurements exceeded the recommended noise level LpCpeak values. The sound level variations of cap firing toys with the number of measurements are shown in Figure 1(c). A total of 195 measurements

were taken and analysed for cap firing, and 190 noise level measurements exceeded the recommended noise level LpCpeak values. In general, a high noise level was observed during the measurement compared to the recommended values. The study clearly indicates that the measured noise level LAeq values and noise peak level LpCpeak values can be above the reference range. It is an unsafe situation that can happen when playing with a toy, and the effect of noisy toys on children's hearing is a major issue.

Noise emission percentage from three categories of toys

By way of contrast, very high noise level parameters were observed during the noise level measurement in the following selected categories of toys. The analysed results are provided in Table 2. According to the cap firing toys, the recommended peak value (LpCpeak) is 125 dB, but 90% of the total number of measurements exceeded

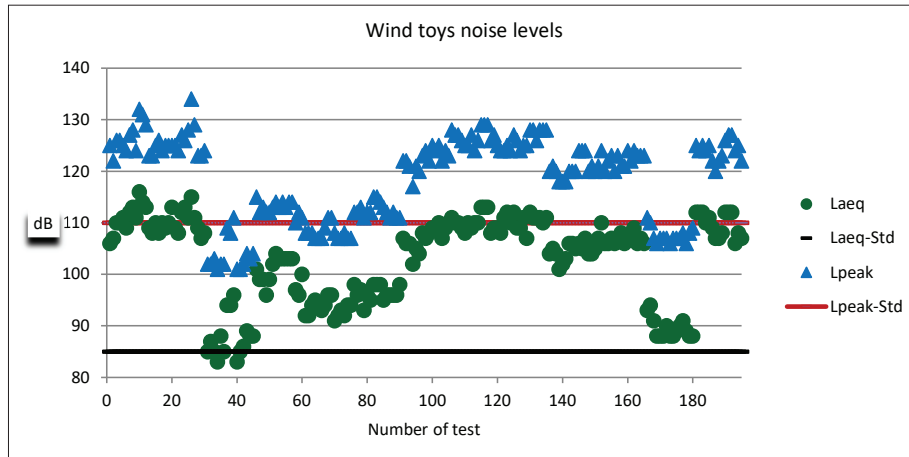


Figure 1(a): The variation of wind toys noise levels

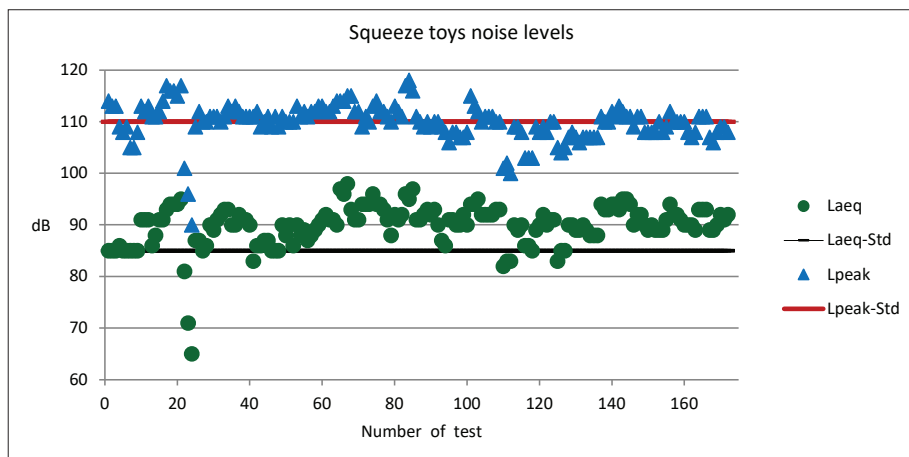


Figure 1(b): The variation of squeeze toys noise levels

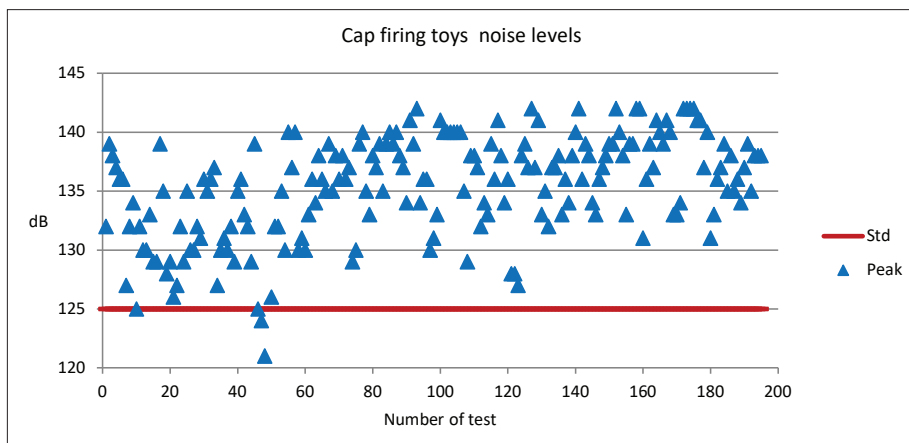


Figure 1(c): The variation of wind toys noise levels

129 dB. For squeeze toys, the number of measurements with noise levels exceeding LAeq surpassed 90% of the total number of measurements, and the peak value (LpCpeak) exceeded 90% of the noise level at 107 dB. Over 80% exceeded recommended levels for wind toys' peak values. The peak values exceeded by 50% of cap firing, squeeze, and wind toys were 136 dB, 110 dB, and 122 dB respectively. The LAeq values exceeded by 50% of squeeze toys and wind toys were 90 dB and 106 dB respectively.

Very high noise levels were observed in the following selected categories of toys. The analyzed results are provided in Table 2. According to the standard, the recommended peak noise level for cap firing toys is 125 dB. It was observed that about 90% of the measurements exceeded 129 dB. However, for squeeze toys, 90% of the LpCpeak measurements exceeded 106 dB. Around 80% of the measurements exceeded the recommended peak noise levels for wind toys. This is an unsafe situation, as mentioned before.

Table 2: Noise limits exceed benchmarks for three categories

Number of noise measurement exceed (%)	Cap firing toys		Wind toys		Squeeze toys	
	LpCpeak	LAeq	LAeq	LpCpeak	LAeq	LpCpeak
90%	129	--	89	107	85	106
80%	131	--	94	109	87	108
70%	133	--	98	112	89	109
60%	135	--	103	118	90	110
50%	136	--	106	122	90	110
40%	137	--	107	123	91	111
30%	138	--	109	124	92	111
20%	139	--	110	125	93	112
10%	140	--	112	127	94	113
Recommended Limits*	125 dB		90 dB	110 dB	85 dB	110 dB

Note: Cap-firing toys do not indicate LAeq. The reason is that the measurement time period is very low.

* EN 71-1 Standard. LpCpeak - Peak LAeq - Equivalent sound pressure level

Pressure level variation with frequencies

The variation of the pressure level of high noise level toys with frequency is discussed in this section.

The variation of C-weighted peak sound pressure level with frequency is shown in following figures. The standard "C" weighted audible frequencies are commonly used for the measurement of Peak Sound Pressure level. Figure 2(a) shows the reference chart for auditory field. Figure 2(b) shows the sound pressure values versus one-third octave band frequency variations for cap firing. Similarly, Figure 2(c) shows the wind toys, and Figure 2(d) shows the squeeze toys. These results clearly indicate that above the 1 kHz frequency range, the peak sound pressure level is 70 dB (C) values. Some values exceeded 100 dB(C) in the above 1 kHz frequency range. According to the figures, it is clear that the selected toys mostly generated higher frequency range

noise levels. The lower frequency values are limited for the toys category selected above. It can be observed that high frequencies are more critical than low frequencies near the measuring location. From Figures 2(b), 2(c), and 2(d), it can be observed that peak sound pressure levels at low frequencies up to about 500 Hz occurred below the loudness level contour, showing that the noise level-induced noise occurred below the human perception level of hearing. But peak sound pressure levels of higher frequencies above 1 kHz occurred above the loudness level contour, showing that noise level-induced noise occurred at higher than the human perception level of hearing.

The study clearly indicates that compared to the reference chart, the noise levels of the toys may affect the human speech range. It is an unsafe situation that can occur when children play with noisy toys, as it can have a major effect on their hearing.

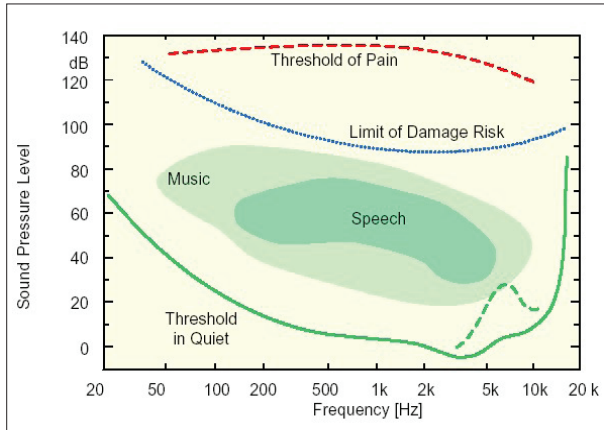


Figure 2(a): Reference curve

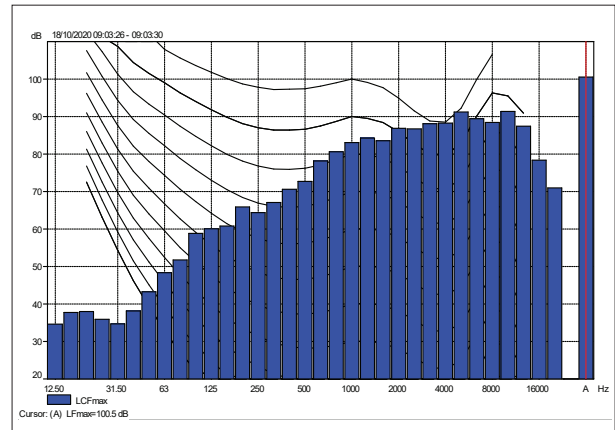


Figure 2(b): Frequency analyses- cap firing toys

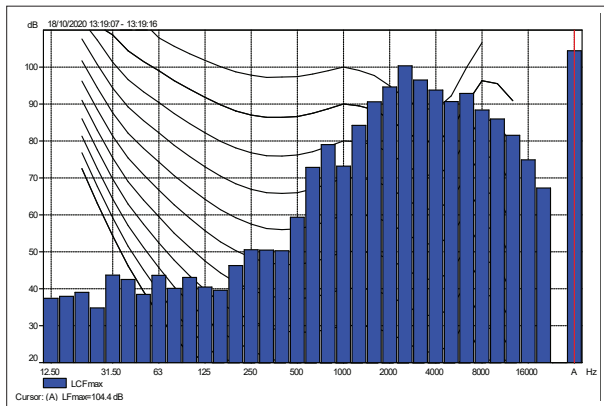


Figure 2(c): Frequency analyses- wind toys

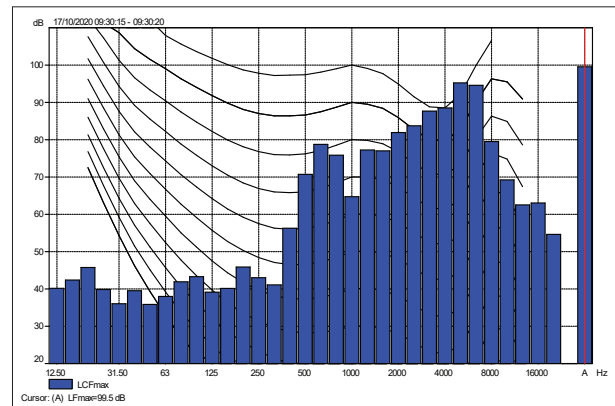


Figure 2(d): Frequency analyses- squeeze toys

CONCLUSIONS

According to the study, most cap firing, wind, and squeeze toys produced higher noise levels compared to international standards. A total of 94 (45.9%) items from the selected toys exceeded prescribed noise levels. The analysis indicates that the peak value (LpCpeak) of cap firing toys exceeded 90% of the noise level (129 dB), squeeze toys exceeded 60% of the noise level (110 dB), and wind toys exceeded 70% of the noise level (110 dB). The 50% exceeded peak values for cap firing, squeeze, and wind toys were 136 dB, 122 dB, and 110 dB, respectively. These toys mostly generate noise levels in the higher frequency range (above 1 kHz), and have limited lower frequency values. The study clearly indicates that compared to reference charts, these toys may influence human speech range, and they are unsafe

for children playing with them, as they can have a major effect on the children’s hearing.

Thus, it is necessary to raise awareness, include warning signs, and enforce acoustic regulations for toys in the Sri Lankan market.

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