Proceedings of the Technical Sessions, 25 (2009) 1-6
Institute of Physics – Sri Lanka

Effect of roadside vegetation on the reduction of traffic noise levels

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ABSTRACT

A study was carried out to determine the effect of roadside vegetation on the reduction of road traffic noise levels under varying traffic conditions. Roadside vegetation which have the potential to act as noise barriers were selected for this study. The road traffic noise was measured together with the parameters that control the vegetation. Several noise level descriptors were recorded together with the A-weighted continuous noise level.

The results show that higher frequency noise (above 4 kHz) is heavily attenuated by the vegetation barriers with virtually no attenuation for low frequency noise (below 100 Hz). The width of the vegetation barrier is linearly proportional to the amount of sound absorption. Without the vegetation barrier, the observed maximum and minimum noise levels were 72 dB(A) and 64 dB(A) respectively. On average, vegetation barriers were able to reduce the noise by 4 dB(A) which corresponds to an approximately 40% acoustic energy reduction. Thus, with careful planning and growing of roadside vegetation, the effect of road noise can be reduced.

1. INTRODUCTION

Noise barriers to block the ever increasing road traffic noise are commonly constructed as walls, earthen berms, or a combination of the two. Walls are most common, and are usually constructed out of dense materials such as concrete or masonry blocks. Earth berms are natural alternative to walls, but require more land space to construct. Walls can be constructed on top of berms in order to raise the overall height of the barrier. Noise barriers reduce noise by blocking the direct travel of sound waves from a given source. Usually, construction costs of noise barriers are quite high.

Some noise reduction measures that are possible on existing roads or on roads that are being rebuilt include creating buffer zones, constructing barriers, planting vegetation, installing noise insulation in buildings, and managing the traffic [1]. Buffer zones are undeveloped in open spaces next to roads. These can be created only when a roadway authority or local government owns roadside land or development rights, in addition to the normal right for building roads, so that building dwellings close to roads can be prohibited in the future. This prevents the possibility of constructing dwellings that would otherwise experience an excessive noise level from nearby roadway traffic. An additional benefit of buffer zones is that they often improve the roadside appearance. However, because of the vast amount of land that must be purchased and because in many cases dwellings already border existing roads, creating buffer zones is often not a viable option.

A number of 'green barrier' systems have been developed which use living plant material in conjunction with soil-filled supporting structures up to 4 m height. In most cases, these need careful maintenance including irrigation in dry weather. If planting fails due to lack of water or disease, the barriers lose their purpose and need time to restore. In the longer term, well-established living barriers may need to be rebuilt if the planted material causes the supporting structure to deteriorate [2]. Any consideration of this type of barrier should take into account of the appropriateness of the planted species to the locality and to maintenance requirements.

Natural vegetation, if high enough, wide enough, and dense enough, can decrease roadway traffic noise [3]. Vegetation plant noise barrier are environmental friendly, having natural appearance and often pleasant in visually inspection. The effectiveness in screening depends on the thicknesses of vegetation belts along the roadways and density of leaves (type of vegetation). Effective noise barriers can reduce noise levels by 10 to 15 decibels. However, the degree of difficulty increases with the level of reduction (see table 1).

Table 1: Reduction in noise against the degree of difficulty [2]

Reduction in sound level	Reduction in acoustic energy	Degree of difficulty
5 dBA	70%	Simple
10 dBA	90%	Attainable
15 dBA	97%	Very difficult
20 dBA	99%	Nearly impossible

This study was carried out to estimate the effectiveness of sound absorption from naturally grown vegetation under varying traffic conditions. Several locations having naturally gown vegetations on roadsides were selected for this study.

2. METHODOLOGY

For each site, two measurement locations within 100 to 200 meters were selected; one as a reference point to measure the unobstructed noise level (where no vegetation to screen the noise) and other as the test point behind the vegetation barrier both with equal distance from the edge of the road. Simultaneous noise measurements were taken so that similar traffic noise conditions will experience both points when the measurement is taken. Several noise level descriptors were recorded during the noise level measurement. The approximate number of vehicles, categorized as heavy, light and very light was also recorded simultaneously with the noise measurements. Noise measurements were carried out approximately 5 m from the edge of the traffic route and 1.5 m above the ground level. In each location, noise measurements were taken for duration 50 minute. The sampling time interval was 5 minute.

The following noise level descriptors were measured simultaneously.

L_{Aeq} - Equivalent continuous sound levels at set time interval.
L_{AF90} - User defined percentile level exceeded for 90% of the elapsed time
L_{AF50} - User defined percentile level exceeded for 50% of the elapsed time
L_{AF10} - User defined percentile level exceeded for 10% of the elapsed time

Noise level was measured using Noise Level Analyzer, BZ 2260 Version 2 Bruel & Kjaer (class-1) and BZ 2250 Noise level analyzer. Noise level meter was calibrated before and after taking measurements on each day using noise level calibrator, B&K Type 4230 which is traceable to primary standards maintained at Korea Research Institute of Standards and Science (KRISS). All noise level data were saved during the measurement and data was analyzed offline by enhanced sound analysis software, Bural & Kajer BZ 7202 which conforms to IEC specific standard.

Measurements were taken in 16 separate locations. Two of such locations are shown in Figure 1.

Figure 1: Examples of roadside vegetation.

3. RESULTS

Table 2 shows the noise measurement in L_{Aeq} dB(A) with and without roadside vegetation together with the traffic parameters.

Table 2: Summary of noise measurements with and without vegetation cover.

Site	Without vegetation dB(A)	With vegetation dB(A)	Reduction dB(A)	Reduction acoustic energy (%)	Average vehicle rate per min		
					Heavy	Light	Very Light
1	69	65	4	60	0.5	2.4	6.8
2	67	60	7	80	0.9	1.4	3.6
3	70	68	2	37	2.9	2.7	5.5
4	72	66	6	75	2.4	2.3	6.3
5	72	66	6	75	3.5	2.1	6.5
6	69	68	1	21	1.7	1.9	3.4
7	68	63	5	68	1.0	2.2	3.1
8	66	61	5	68	1.1	2.3	6.2
9	65	62	3	50	1.1	4.0	6.1
10	64	62	2	37	0.6	1.6	3.6
11	68	64	4	60	0.8	2.5	2.8
12	66	61	5	68	1.0	1.3	2.9
13	69	63	6	75	3.1	3.3	5.6
14	68	66	2	37	1.5	0.9	2.5
15	69	67	2	37	1.4	1.8	4.3
16	72	66	6	75	3.0	1.5	5.0

According to Table 1, the selected sites, road traffic noise varied between 72 dB(A) and 64 dB(A). On average, vegetation barriers were able to reduce the noise by 4 dB(A) which corresponds to an approximately 58% acoustic energy reduction. In some cases, due to the thick growth of the vegetation, up to 7 dBA which corresponds to 80% acoustic energy reduction was seen.

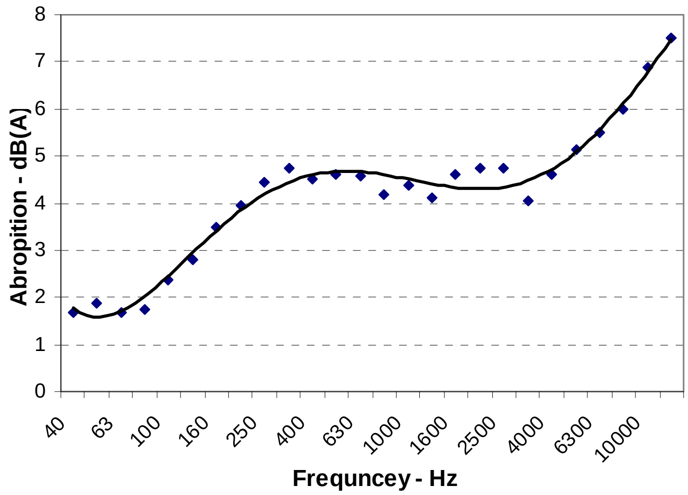

Figure 1: Noise absorption for range of frequencies.

In figure 1, average noise absorption for different frequencies is shown. A non linear pattern with higher absorption for higher frequencies is seen. Rate of absorption becomes quite steep above 4 kHz and falls below 2 dBA below 100 Hz. In the frequency range from 400 Hz to 4 kHz, a constant absorption rate is seen. The measurements clearly show that higher frequency noise is heavily attenuated by the vegetation barrier and virtually no attenuation for very low frequency noise.

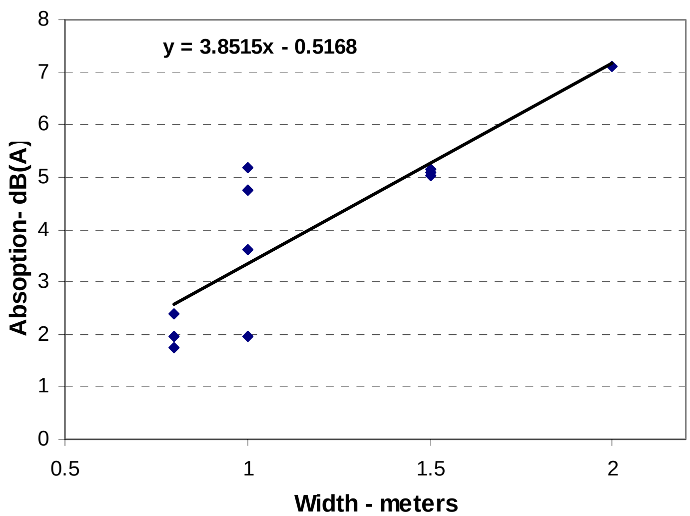

Figure 2: Variation of noise absorption with the vegetation barrier width.

Figure 2 shows the variation of noise absorption rate with the width of the vegetation barrier. Although the estimating the width has large uncertainty, it can be seen that absorption is linearly proportional to the width of the vegetation barrier. In order to achieve an absorption of 5 dBA or better, width of the vegetation barrier must be at least 1.5 meters thick.

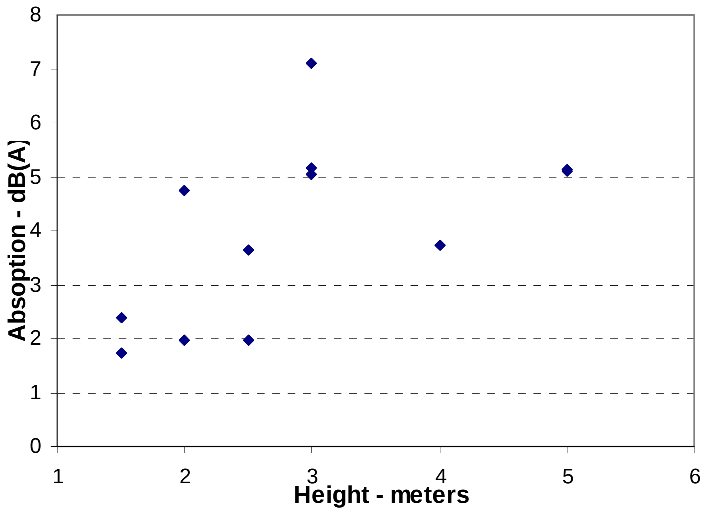

Figure 3: Noise absorption with vegetation barrier height

The variation of noise absorption with vegetation barrier height in shown in Figure 3. Data do not show a clear pattern. However, the reader should note that estimating the height of the vegetation barrier has many problems. When compared with vegetation barrier height and width, the most effective parameter is the vegetation barrier width. This result is not surprising since most of the noise generated in road traffic is in the range from 0.5 meter to 1.5 meter from the ground levels.

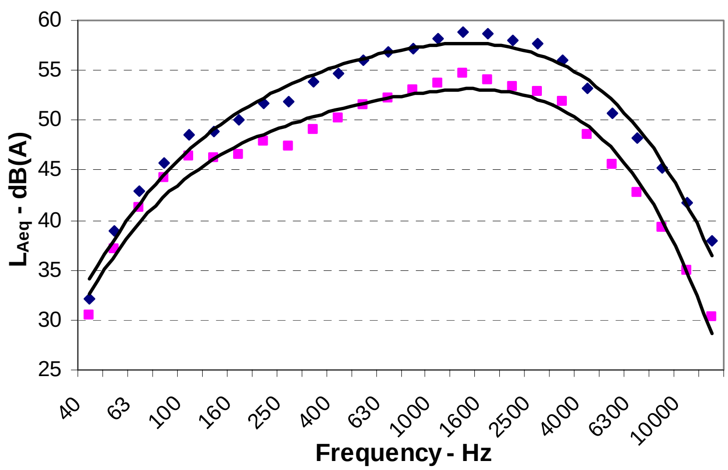

Figure 4: Road noise with and without vegetation barrier

Figure 4 shows road noise level variation spectrum, i.e. the road noise levels with and without the vegetation barrier. Data shows that most of the high noise values are in the mid frequency range. In the mid frequency range, 4 dB(A) or above absorption rates were observed (see figure 1).

4. CONCLUSIONS

According to this study, on average, vegetation barriers were able to reduce the noise by 4 dB(A) which corresponds to an approximately 58% acoustic energy reduction. The measurements clearly show that higher frequency noise is heavily attenuated by the vegetation barrier and virtually no attenuation of low frequency noise. The noise absorption is linearly proportional to the width of the vegetation barrier. In order to achieve higher absorption of 5 dBA or better, width of the vegetation barrier must be at least 1.5 meters thick. No clear dependency on the height of the vegetation barrier. Data shows that most of the high noise values are in the mid frequency range where 4 dB(A) or above absorption rates due to vegetation barriers were observed.

Acknowledgements: Financial assistance given by the International Program for Physical Sciences of the Uppsala University, Sweden for the research grant SRI: 01/3 is greatly acknowledged.

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