Investigation of Possible Vegetation for a Natural Sound Barrier

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ABSTRACT : Noise pollution has been identified as the third most hazardous type of pollution in the world. Vegetation was used for experiments recently to check the effectiveness as a sound barrier. This research includes a qualitative analysis of natural vegetation fences to identify the parameters contributing to noise attenuation and its effectiveness. A-Weighted noise levels were measured for frequencies ranging 125 Hz to 16 kHz upto 9m from barrier using a sound level meter with 1:1 octave band. Same test was carried out for artificial walls to compare the effectiveness of vegetation barriers. The identified parameters contributing to noise attenuation were thickness of the barrier, leaf density (primary) and height (secondary). According to results, a vegetation barrier of considerable thickness, height and dense leaves can achieve the effect of a low height artificial barrier. Although vegetation attenuate noise, it seems to be not enough to reduce the current noise levels below the level that can be borne without annoyance.

1 INTRODUCTION

Sri Lanka is one of the rapid developing countries in the world. While proceeding with development activities, precautions should be taken to minimize adverse environmental impacts. This is one of the major concerns in engineering as well. There are many environmental impacts that have been encountered in the development projects. According to the World Health Organization, noise pollution is the third most hazardous environmental pollution type, which proceeded by only air (gas emission) and water pollution.

Noise can define as unwanted sound, allowing sound to interrupt the conversation, or cause pain(Pudjowati et al.2013). Noise can be generated due to industrial activities, traffic/ transportation or due to city settlement noises. McMichael (2000) states thatspecially dense transportation systems, including roads, railways, and air traffic have caused environmental noise (also known as community noise) pollution. With the development of roads, there is a high vehicular density and with the increasing traffic and road usage, the sound levels have increased alarmingly. As the busiest city in Sri Lanka, Colombo faces huge traffic congestion daily which propagates to Colombo suburbs. Setiawanet al(2001) mentioned that traffic noise consists of the sound generated from motor vehicles, especially from vehicle engines, exhaust, due to the interaction between the wheels to the road, heavy vehicles (trucks, buses) and passenger cars are the main source of noise on the highway. The level of noise disturbance from traffic noise varies due to the level of the voice, how often it occurs within a unit of time and the frequency of the sound it produces (Fang 2005). A study done by King and Davis (2003) on how noise exposure affects the human health state that exposure to noise less than 75dBA over a 24hour period does not cause any permanent hearing loss. At the same time exposure to 75dBA over 24 hour period may cause permanent damage to human health. Therefore, according to these ranges, noise above 55 dB is deserves to get attention because of disturbing the comfort of hearing.

According to Noise Control Regulations, the highest levels of allowable noise have been determined as 75dBA for automobiles, 80dBA for buses and 85dBA for heavy vehicles and Lorries. It was also found out by Pudjowati et al (2013) that the intensity of the sound produced from the noisy traffic is about 80-88 dB.

There is a major negative impact on the quality of life in most of the cities due to high noise levels, so that proper precautions should be taken to reduce the noise levels. Since traffic noise is the main source of sound pollution, reducing excessive traffic noise will be an effective solution. Noise levels near roads can be reduced using many tech-

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niques. The use of a sound barrier is one of the concepts, which is widely used in most of the developed countries. Sound barriers can be either walls or earth fills. Kalansuriya et al. (2006) suggested that sound levels can be controlled by either creating buffer zones, installing sound barriers, using sound insulations for building etc. It is better to implement a natural sound barrier system to incorporate sustainability and green concepts in designs, which will positively contribute to reduce noise pollution. Therefore, this research involves qualitative analysis to find the effectiveness of using vegetation barriers to reduce traffic noise levels.

2 METHODOLOGY

Investigation of possible vegetation for a natural sound barrier is of concern worldwide. It has been the focus of many researchers to find the effectiveness of using vegetation as a traffic noise screening method. Most of them have studied the noise attenuation variations with respect to many parameters, which could contribute to noise attenuation, in order to develop a proper barrier to obtain the maximum attenuation possible. Through those research data practical issues and difficulties that can occur in experiments were identified. Information about relevant and applicable methodologies to conduct experiments were gathered.

Locations and vegetation barrier types for testing were selected carefully to minimize the practical errors especially due to environmental effects. Barriers near roads were avoided as much as possible to avoid high ambient noise levels. On the other hand, as a 9m distance is required on one side to take readings and 3m on the other side to place sound generator, any location with a barrier cannot be selected. Therefore, considering all these facts, the tests were conducted on vegetation barriers at Gampaha, Peradeniya Botanical Gardens and at Police College premises, Kalutara. Experimental work was carried out to obtain noise attenuations for different types of barriers.

Data analysis was performed to identify the factors affecting the noise attenuation and the variations of attenuation. In order to do that, the effective noise level at each location was found for both with barrier and without barrier criteria. Noise level on the side of source was also measured. From that, relative sound reduction at each location for both with barrier and without barrier criteria was obtained. The difference of the measurements at each location was calculated as the attenuation of noise. With the use of these values, analysis was done to check the noise attenuation variation with respect to thickness and height of barrier. Noise attenuations in artificial walls were also measured using the same procedure.

The grouping arrangement used for analysis is as follows:

- Natural barriers with same height and varying thicknesses including attenuations of a block wall of same height
- Natural barriers with same thickness and varying heights
- Artificial walls with different heights to get the noise attenuation variation of walls.
- Low height artificial walls and thick, high vegetation barriers for comparison of noise attenuation.

3 EXPERIMENTAL WORK

3.1 *Instruments*

Sound level meter with 1:1 octave band was used to measure the noise levels and A- weighted noise readings were taken for analysis. A generated noise level consisted of frequencies ranging from 125Hz to 16 kHz was played using a buzzer. A tripod was used to keep the sound generating buzzer at a fixed height.

3.2 *Test procedure*

Testing procedure in detail can be described as follows.

- Barrier details (Height, Thickness, Length and vegetation type) were recorded
- Sound generating buzzer was placed on a tripod at a fixed height of 1.5m (source height was selected according to information collected from literature)
- Sound generator was placed at a distance of 2m from the barrier.
- Distances at which measurements are taken were marked. 1m on the side of sound source, 1m, 3m, 5m, 7m, 9m locations in the other side of the barrier.
- Required noise measurements were taken as given in Table *1*.

Table 1 Measurements

Reading	Description
1	Ambient noise level
2	1m from barrier in the side of sound source.
3	1m behind the barrier (other side of barrier)
4,5,6,7	3m, 5m, 7m and 9m from the barrier
5	Ambient noise level

Test procedure can be illustrated in figures as below.

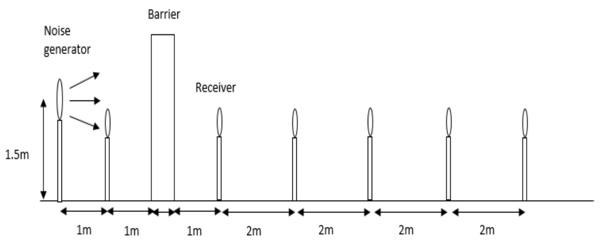

Fig. 1 Test arrangement for readings with barrier

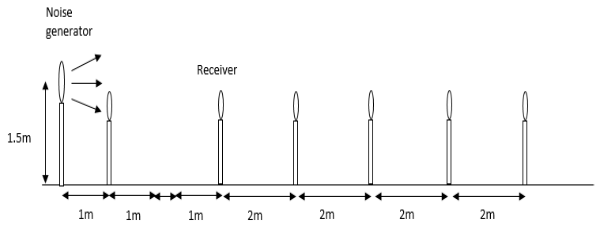

Fig. 2 Test arrangement for readings without barrier

- Same procedure was followed to take readings without barrier. Here the barrier thickness was also included when marking positions to take measurements.
- Measurements were taken for 34 barriers with different vegetation types, heights and widths. This include artificial barriers with different heights to compare the effectiveness of the vegetation barriers.
- Reliable data of 18 barriers have been analysed to obtain the final outcome.
- Vegetation Species types used for testing are as follows:
  - *Heliconiapsittacorum*
  - *Acalyphasiamensis*
  - *Codiaeumvariegatum*
  - *Excoecariacochinchinensis*
  - *Vanda type Orchid*
  - *Phyllanthusmyrtifolius*

4 DISCUSSION

According to the results obtained, for all barrier types, noise attenuation in lower frequencies (125Hz and 250Hz) is very low and can be considered as negligible. Very close to the barrier, there is a small attenuation, but when moving away from the barrier the attenuation is negligible. In middle frequencies (500Hz to 2 kHz), there is a considerable attenuation. In high frequencies (4 kHz to 16 kHz), high attenuation was achieved in most of the barriers. Usually their attenuation is varying in the range of 5dBA to 10.93dBA near the barrier.

This implies that vegetation barriers are good in attenuating higher frequencies. Of the higher frequencies, 16 kHz has the peak attenuation of 10.93dB (A) and the value was recorded for a thick leaf vegetation type called *Helicornia psittacorum* which has high leaf density. On the other hand, almost all the results show that, very close to the barrier, the attenuation of noise is higher and it eventually reduces when moving away from the barrier.

When considering the parameters contributing to the noise attenuation, it can be clearly seen that the thickness of the barrier has a positive effect on noise attenuation. This implies that when barrier thickness increases, noise attenuation also increases in each barrier set grouped considering the height. Therefore, barrier thickness can be identified as a primary factor contributing to noise attenuation.

Leaf density and the leaf thickness may also have a positive effect on noise attenuation because most of the barriers with high leaf density and leaf thicknesses have achieved higher attenuations. According to the analysis done for barriers with same thickness and varying heights, it can be seen that some barriers have attenuations greater than the attenuations recorded in the highest barrier of the same thickness. In barriers with thick leaves such as *Helicornia psittacorum* and *orchid*, the noise reduction was high. Also in some of the high leaf density *Acalypha siamensis* and *Excoecaria cochinchinensis barriers*, the attenuations were high.

According to the analysis of noise attenuation of barriers with same thickness with respect to height, there are some random variations as mentioned above. Therefore the noise attenuation variation with height of barrier cannot be readily interpreted to provide a conclusion. Therefore, the height variation can be taken as a secondary parameter.

In this research, some of the artificial walls with different heights have been tested to check the noise attenuations through them. Unlike vegetation barriers, noise attenuation in artificial walls was directly proportional to the height of wall. A quantitative analysis has been carried out to check whether vegetation barriers can replace artificial walls. The analysis was done considering some walls with a range of heights and vegetation barriers with high thicknesses and leaf densities. According to that, a vegetation barrier of a considerable height can achieve the noise attenuation of an artificial wall of low height (about 1.5m-1.6m) if it is wide enough and dense enough.

5 CONCLUSION

The recorded noise level due to transportation is in the range 80dBA to 88dBA. The comfortable noise level for hearing can be taken as 55dBA. Therefore, least of at a noise reduction of 25dBA should be achieved to reduce the levels to a safe level. Other than reducing the noise levels emitted by the sources, the best way is to reduce the effect to the environment from noise by establishing barriers. According to the results obtained from the analysis, vegetation barriers can achieve noise attenuation to a considerable level. The maximum attenuation observed was 10.93dBA at 1m distance from a *Helicornia psittacorum* barrier of height 2.25m and thickness of 1.2m. Although there is a positive effect from vegetation for noise attenuation, the reduction is not enough to reduce the noise to the required level. When comparing vegetation barriers with artificial walls, the attenuation in walls is much higher than in vegetation barriers. However, thick vegetation barriers with considerable height can achieve attenuations similar to that of artificial walls with low heights (around 1.5m to 1.6m).

6 RECOMMENDATIONS

This research mainly focused on a qualitative analysis to check the effectiveness of vegetation fences as a sound barrier. It would be better to perform a quantitative analysis to find the contribution of each parameter for the noise reduction. In addition, the scope does not contain study of vegetation belts like tree estates or forests. Here it has considered the effect of vegetation fences grown in households to fulfill the purpose of a wall.

Rather than using a single type of vegetation for a barrier, a mixed stand would give a different result in noise attenuation. If a barrier can be developed using various types of dense plants with thick leaves, a better result could be obtained. Rather than conducting tests in the natural environment, if pre-prepared barriers could be used in a selected site with controlled ambient noise levels, more accurate results could be obtained.

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