TRAFFIC NOISE ABATEMENT THROUGH TREE AND SHRUB VEGETATION

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Abstract

Traffic noise abatement through tree and shrub rows was studied on the main highway between Peshawar and Islamabad/Rawalpindi. Road stretches with trees and shrubs were selected all along this highway. Noise of traffic was measured behind the vegetation stretches and controled with a Noise Level Meter. It was found that the trees alone and in combination with shrubs could cut down the traffic noise by 5-8 dB(A). Trees in combination with shrubs proved more effective and multiple rows of young trees of *Eucalyptus camaldulensis* in combination with *Tecoma stans* gave a maximum reduction of 8 dB(A) in the traffic noise. It is recommended that multiple rows of evergreen trees in combination with shrubs must be planted along the highways, as a measure to cut down traffic noise in addition to other environmental benefits.

Introduction

Noise is defined as unwanted sound (Staudt, 1984) and has become a major health and environmental hazard of modern life due to urbanization, growth of industries and communication etc. Road traffic is one of the major sources of noise in urban living. High and constant noise produces many psychosomatic health problems in human beings (Grandjean, 1981).

High noise interferes with the "Hearing Mechanism", producing auditory fatigue in 90 dB(A) region, manifested as whistling and buzzing sensation leading to deafness. Repeated or continuous exposure to noise around 100 dB(A) may result permanent hearing loss. Noise exposure upto 120 dB(A) is high enough to rapture the membrane of the ear and causes complete hearing disability.

Besides auditory system the high noise also impacts other physiological functions. Noise adversely effects the "Cardiovascular System" due to the

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constriction of small blood vessels, causing changes in blood pressure and heart rate. "Digestive System" may be disturbed due to increased intestinal motility producing diarrhoea or loose motions. Eyes may also be affected by high noise like narrowing of pupils and impaired visual and colour perception.

Noise interferes with speech and communication through its masking effect. Noise could be a source of permanent annoyance and disturbed mental concentration and efficiency (Anonymous, 1986).

Interference in sleep and comfort with personality and behavioural disorders are common noise induced complaints. A research report from France showed that 70% of people in Paris are suffering from mental disorder and they consider noise, a main reason for it.

More than 10 million Americans have had their hearing damaged by noise and about 20 million are regularly exposed each year (National Institute of Health, USA 1988). European community puts a noise limit of 77 dB(A) on passenger cars and 84 dB(A) on heavy goods vehicles running on the roads (WHO, 1961). The US Environmental Protection Agency has recommended that overall out door noise should be limited to an average of 55 dB(A) to prevent noise induced disorders. However, a noise level of 85 dB(A) is recommended by Environmental Protection Agency (EPA) in Punjab, Pakistan.

Experimental works on noise propagation have shown that shrubs and trees, if correctly planted, can play an important role in reducing noise. The size of the tree and density of the stand also affect the value of the forest as a sound barrier. Dense stands of trees are particularly effective on level grounds or where the noise source is lower than the subjects.

Material and Methods

I. Material

The objective of the study was to find out the effect of different types of road side vegetation to abate traffic noise. For this purpose road stretches having road side planting of trees and shrubs in different combinations were selected on the main highway between Peshawar-Islamabad/Rawalpindi. Most of the vegetated/ treatment stretches were on the double-lane, dual-carriage road and a few on double-lane, single-carriage road.

Initially, 25 candidate treatment stretches were marked. The information on species (trees and shrubs), number of rows, height, diameter, spacing between plants and rows, approximate age of the crop and width and length of vegetation belt were recorded.

Out of these 25 candidate sites, 5 treatment stretches were finally selected for making noise level measurements. These 5 stretches represented all combinations of vegetation available all along the road length of 160 km from Peshawar. These treatment stretches were marked as A, B, C, D and E. Complete description of treatment stretches is given in Table 1.

To compare the noise observations from the treatment stretches with controls (non-vegetated road stretches), 3 stretches marked as C-1, C-2 and C-3 were also selected along this highway as controls.

Table 1. Description of the treatment stretches

Treatment stretches	Distance from Peshawar (km)	Vegetation Composition		Mean Tree Height (m)	No. of Tree Rows	Spacing (m)	Crown density	Size of Vegetation belt (m)
		Trees	Shrubs					
A	22	Mature trees of Eucalyptus (*E. Camaldulensis*), shisham (*Dalbergia sissoo*) and Jacaranda (*J. mimosaefolia*)	*Tecoma stans, Punica granatum* and *Callistemon lanceolatus*	10	5	2x2	0.7	6x95
B	35	Young trees of Eucalyptus (*E. camaldulensis*)	*Tecoma stans*	4	35	1.5x1.5	0.8	35x160
C	92	Mature trees of Eucalyptus (*E. camaldulensis*) having an age of 12-15 years		12	10	2.5x2.5	0.5	20x110
D	128	Sub-mature trees of shisham (*Dalbergia sissoo*)	Young trees of ipil ipil (*Leucaena leucocephala*), Phulai (*Acaci modesta*), babul (*A. nilotica*) and Kner (*Nerium odorum*)	9	10	3x3	0.7	30x170
E	120	Old trees of shisham (*Dalbergia sissoo*) and 7 years old trees of Eucalyptus (*E. camaldulensis*)		9	10	3x3	0.7	30x100

II. Methods

i. Recording of Data

Single day noise measurements were carried out for four hours at each treatment stretch (including controls), 2 hours in the morning (from 10:00 A.M. to 12:00 Noon) and 2 hours in the afternoon (from 2:00 P.M. to 4:00 P.M). This was to cover any variation in traffic intensity between morning and afternoon hours. Noise level data were recorded systematically at an internal of 5 minutes (noise of first vehicle passing over 5th minute). In all 48 noise observations were made each day for each stretch. The observations were made only on the working days of the week.

Noise of traffic behind the treatment and control stretches was measured with a noise level meter "INDUNORM" at distances of 20, 40 and 50 meters from the road edge. The noise level measurement distance of 20, 40 and 50 m was in view of different widths of vegetation belts of the treatment stretches.

ii. Data Analysis

Simple arithmetic mean of tree and shrub parameters for each stretch were computed. Similarly for noise level data simple arithmetic averages were calculated for various distances for treatment and control stretches. Mean traffic noise values measured on treatment stretches were compared with the mean noise values measured at the corresponding distances on the control stretches. For the significance of difference between the mean noise values of treatment and control stretches, Z-test was performed (Nolthenius, 1984).

Results and Discussions

Treatment Stretches and Noise Levels

The mean noise levels in dB(A) with maximum and minimum values at various treatment and control stretches are give in Tables 2 and 3.

As given in Table 2, the mean noise levels were 71, 66 and 67 dB(A) for treatment stretch A, B and D for a noise measurement distance of 20, 50 and 50 m, respectively. These stretches presented a combination of trees and shrubs. Treatment stretch C and E comprising of only trees gave a mean noise level of

71 and 68 dB(A) for a distance of 40 and 50 m, respectively. No valid comparison of mean noise levels among the treatments could be made because of different noise measurement distance and thickness and composition of vegetation belts.

Table 2. Traffic noise levels at different combinations of vegetation

Treatment Stretch No.	Distance from outer road edge (m)	Noise level dB(A)			
		Minimum	Maximum	Mean	Standard deviation
A	20	67	74	71	± 1.82
B	50	61	72	66	± 2.29
C	40	66	75	71	± 2.03
D	50	61	73	67	± 2.81
E	50	61	75	68	± 3.16

Control and noise levels

As given in Table 3, the mean noise levels at control stretches at the distance of 20, 40 and 50 m were 76, 76 and 74 dB(A), respectively.

Table 3. Traffic noise level at control stretches

Control stretches	Distance from outer road edge (m)	Noise level dB(A)			
		Minimum	Maximum	Mean	Standard deviation
C-1	20	73	81	76	± 1.76
C-2	40	72	72	76	± 2.33
C-3	50	71	71	74	± 1.88

Noise abatement by tree and shrubs rows

The results of Z-test (Table 4), showed that all the treatment stretches gave a highly significant reduction in the traffic noise against control. Similarly Z-test performed by Nolthenius (1984), found a highly significant reduction in noise levels by 3 year2 old crop of *Salix* spp.

Table 4. Results of Z-test applied to mean traffic noise level of treatment and control stretches.

Vegetation Stretch	Calculated value of 'Z'	Tabulated value of 'Z'	Remarks
A	14.26	2.575	Highly significant
B	19.17	2.575	Highly significant
C	12.87	2.575	Highly significant
D	14.81	2.575	Highly significant
E	11.25	2.575	Highly significant

A comparison of mean noise values at different treatment and control stretches has been made and the results of this comparison are given in Table 5 below:

Table 5. Reduction in traffic noise by different combinations of vegetation

Treatment stretches	Distance from road edge (m)	Mean noise level at treatment stretches [dB(A)]	Mean noise level at control stretches [dB(A)]	Noise Reduction Db(A)
A	20	71	76	5
B	50	66	74	8
C	40	71	76	5
D	50	67	74	7
E	50	68	74	6

As shown in Table 5, all the treatment stretches gave an average noise reduction of 5 to 8 dB(A). The maximum noise reduction of 8 dB(A) was given by treatment stretch B, having a combination of young trees (3-4 years) of Eucalyptus (*E. camaldulensis*) in combination with shrubby growth of *Tecoma stans*. This provided a complete and thick screen of foliage right from the ground upto a height of 4 m.

Treatment stretch D, with a upper storey of mature trees of Shisham *(Dalbergia sissoo)* and dense under-storey of Ipil Ipil (*Leucaena leucocephala*), Phulai (*Acacia modesta*), Kikar *(Acacia nilotica)* and scattered shrubs of *Nerium* *odorum* gave the next higher reduction of 7 dB(A) in the traffic noise. Though this stretch likewise, gave a good combination of different kinds of vegetation but the noise reduction was less by 1 dB(A) than the treatment stretch B. This could probably be due to the less thickness of this vegetation belt than stretch B. Similar results of noise reduction of 7 dB(A) by 33 m wide belt of *Tsuga canadensis* have been reported by Aylor (1981).

The treatment E, with a combination of mature Shisham (*Dalbergia sissoo)* and *Eucalyptus camaldulensis* cut down the traffic noise by 6 dB(A). Due to absence of shrubs and high crowns of mature trees, this stretch offered comparatively less obstruction in the flow of sound waves.

A minimum noise abatement of 5 dB(A) was given by stretches A and C, comprising of mature trees of Eucalyptus, shisham (*Dalbergia sissoo*), and jacaranda (*Jacaranda mimosaefolia*) with under growth of shrubs like *Tecoma stans, Punica granatum* and bottle brush (*Callistemon lanceolatus*). Though the combination of this vegetation seemed to be good, but this could not provide a perfect screen due to the high crowns of the mature trees, leaving a gap between shrub layer and top canopy.

From the above discussion, it has become clear that the treatment stretches where only mature trees were growing, irrespective of species, gave less reduction in traffic noise. But wherever, trees were planted in combination with shrubs gave better noise abatement due to the collective effect of trees crowns and a shrubby screen at lower level. However, treatment stretches A and E, showed least reduction in traffic noise which could also be due to the smaller width of the vegetation belt.

Conclusions and Recommendations

Based on the results of the study the following conclusions and recommendations are drawn:

I. Conclusions

Trees and shrubs reduced on an average 6 dB(A), [5-8 dB(A)] in traffic noise.

- Patches of mature trees without any undergrowth of shrubs have lesser effect on noise reduction as compared to the stretches having young crop of trees in combination of shrubs.

- Young crop of evergreen trees and shrubs closely planted in a width of more than 30 m, gave a maximum reduction in noise level.

- Vegetation is the efficient, economical, aesthetically and environmentally desirable mean of traffic noise attenuation.

II. Recommendations

Noise could be controlled in two ways. It is either at the source or the protection of subjects against the harmful effects of noise by providing barriers against the noise transmission. Besides many others, trees and shrubs could be planted, in different ways, to serve as barriers to check and reduce the intensity of sound waves emitted by a source. In the following lines some options for making tree and shrub barriers to abate traffic noise are discussed.

- A mixture of trees and shrubs should be preferred over trees or shrubs alone.

- Spacing between plants should be kept minimum to create perfect barrier.

- Shade bearing shrubs should be planted in combination with trees attaining a maximum height of 6 to 8 m.

- Planting is not recommended on sharp curves and at road intersections for safety reasons.

Choice of species

In addition to the above mentioned recommendations, following should be considered while choosing tree and shrub species for planting along the road sides for noise attenuation.

- Species should have a thick, low, evergreen and spreading crown where space permits, otherwise pyramidal or columnar crowns.

- Species should have a moderately fast rate of growth.
- Should be wind firm in view of the traffic safety.
- Should not bear large or edible fruits.
- Species with light coloured or white bark should be preferred.
- Species selected should be suited to the site conditions.

Some Tree and Shrub Species Recommended are given in the Annexure.

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Annexure

The following trees and shrubs which are considered best for noise control are recommended to be planted along the highways/road sides.

S. No.	Local name	Botanical name	Habitat
a. Trees			
1.	Sirin	*Albizia lebbek*	Deciduous
2.	Weeping willow	*Salix babylonica*	-do-
3.	Poplar/Safeda	*Populus* spp.	-do-
4.	Ipil Ipil	*Leucaena leucocephala*	-do-
5.	Shisham	*Dalbergia sissoo*	-do-
6.	Mulberry	*Morus alba*	-do-
7.	Satni	*Alstonia scholaris*	Ever Green
8.	Neem	*Azadirachta indica*	-do-
9.	Amaltas	*Cassia fistula*	-do-
10.	Saru	*Cupressus sempervirens*	-do-
11.	Silver oak	*Grewillea robusta*	-do-
12.	Frash/Loa	*Tamarix aphylla*	-do-
13.	Safeda/Ilachi	*Eucalyptus* spp.	-do-
14.	Kikar/Babul	*Acacia nilotica*	-do-
15.	Arjun	*Terminalia arjuna*	-do-
16.	Bottle brush	*Callistemon lanceolatus*	-do-
b. Shrubs (large)			
1.	Wilayati kikar	*Acacia* spp.	Deciduous
2.	Banna	*Buddleia asiatica*	Evergreen
3.		*Cassia glauca*	-do-
4.	Kaner	*Nerium odorum*	-do-
5.	Peela tecoma	*Tecoma stans*	-do-
6.	Parkinsonia	*Parkinsonia aculeata*	-do-
c. Small and spreading shrubs			
1.	Sanatha	*Dodonea viscosa*	Evergreen
2.	Jasmin	*Jasminum pubescens*	-do-
3.	Ghaner	*Lantana indica*	-do-
4.		*Cassia artemesoides*	-do-