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Noise Attenuation by Landscape Woody Plants[1]

-Comparisons as a Hedge Species Between Japanese Spindle Tree & Oriental Arbor-vitae-

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造景樹木의 騷音減衰効果에 關한 硏究[1]

-사철나무와 측백나무 樹壁의 比較分析-

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ABSTRACT

Effects on noise attenuation of the hedge species, *Thuja orientalis* L. and *Euonymus japonicus* Thunb., widely used as road side hedges, were analysed at the frequencies of 1,000, 2,000 and 3,150 Hz., respectively. The present experiments were carried out both in the field and in a Semianechoic Chamber. As increasing the distances from the noise source, attenuation rates of noise level were increased at high frequencies. But the attenuation rates of the noise level at low frequencies showed varied as the distances increased, and this trend appeared to be caused by the influence of ground waves.

Generally, in this experiment, *Thuja orientalis* L., which is a coniferous species, showed more effective on the abilities of noise attenuation than that of *Euonymus japonicus* Thunb., which is a broad-leaved evergreen species.

Key words : *noise attenuation* ; *Thuja orientalis* ; *Euonymus japonicus*.

要 約

本 硏究는 현재 가로변의 樹壁造成用으로 널리 使用되고 있는 사철나무와 측백나무의 騷音 減衰程度를 파악하기 위하여 實施하였다. 騷音減衰에 對한 野外實驗의 경우, 수벽을 대상으로 하여 音源을 각각 100 cm, 200cm 및 400cm의 거리를 두었으며, 受音點은 각각 0cm 및 100cm의 두 종류로 하였다. 한편 音響實驗室內에서의 實驗은 사철나무와 측백나무의 單木을 對象으로 하였으며, 音響實驗室의 空間的인 規模의 制限으로 인하여 音源은 0cm로 固定시켰으며, 受音點은 對象樹木으로 부터 각각 45, 90 및 180cm의 3가지로 區分하여 實施하였다. 각각의 實驗에 使用된 音源은 室內·室外 實驗 모두 1,000, 2,000 및 3,150 Hz였다. 樹木의 騷音減衰率은 室內 및 室外 모두 高周波 領域에서 거리가 멀어짐에 따라 騷音이 減少되었으며, 低周波 領域의 경우는 減衰의 比率이 一定치 않았는데, 이것은 地面反射波

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의 影響으로 思料되었다. 一般的으로 騷音의 減衰程度는 常綠闊葉樹種인 사철나무 보다는 常綠針葉樹種인 측백나무의 경우가 더 効果的인 것으로 思料되었다.

INTRODUCTION

Nowadays human beings are surounded by various kinds of pollution, such as air pollution, water pollution, soil pollution and noise pollution, etc. Among them, the noise pollution is one of the deteriorating elements of the quality of the living environment in the urbanized cities. It is well known that the noise is commonly thought of an excessive or unwanted sound. Noise, which is considered a invisible pollution, involves both physiological and psychological effects (Grey, 1973). Physiologically, an excessive noise is capable of producing hearing loss, while psychological effects are more widespread (Ward, 1969).

In order to manage in reducing the noise problem, tremendous strides have been made, but very little progress has been made in the landscape (Carpenter, Walker & Lanphear, 1975). Non-living kinds of materials are not reasonable measures in view of their visual appearence, so the possibilities of using vegetation to reduce outdoor noise has been explored and merits consideration (Buellen & Fricke, 1982 ; Fricke, 1984). It is well known that the the plant materials can absorb and scatter sound waves (Robinette, 1969 ; U.S. Department of Transportation, 1976 ; Kragh, 1979). A properly designed fence or hedge can also provide visual and acoustical separation between highway noises sources and adjacent land areas. This method can reduce noise as much as 15 dB. level (California Division of Highways, 1972). For that reason, various kinds of plant materials have been pursued to perform this function. Martins and Linskens (1976) reported that various kinds of plant materials could partially fulfill the noise control by checking the total background noise, which is increasing at the rate of 3 dB. level *per* year. However, very little work has been done on the role of plants in the noise abatement (Eyring, 1946 ; Embleton, 1963 ; Martins and Linskens, 1976 ; Fricke, 1984 ; Görk *et al*, 1984).

The present paper is on the investigation of noise abatement using hedge species, and *Thuja orientalis* L. and *Euonymus japonicus* Thunb. were used for the present study

MATERIALS AND METHODS

The experiment on noise attenuation by hedge species was carried out at the nursery, Yeungnam University, as well as an individual hedge tree tests were also carried out in the Semianechoic Chamber, Laboratory of Acoustics, Department of Physics, College of Science, Yeungnam university. The placements of both plant materials and equipment are shown in Fig. 1 and 2. Temperature and humidity at the testing sites were measured with Thermohygraph (No. 7010, Sato Company).

The plant materials used were as follows ; *Thuja orientalis* L. and *Euonymus japonicus* Thunb. For the Semianechoic Chamber tests, the heights and width of plant materials were 160 cm and 45 cm, respectively. For the field tests on hedge, the heights, widths and lengths of the hedges were 130 cm, 100 cm and 1,500 cm, respectively. Both experiment materials were healthy, and estimated at about 10 years old. But the plant material of *Euonymus japonicus* Thunb. was defoliated and decayed about 15 cm above from the ground.

For the experiment on noise attenuation, Audio Speaker Wide Band Signal Generator (ARF-300, Belco Company), and Impulse Precision Sound Level Meter (Type 1616, Bruel & Kjaer Company), Octave Band Pass Filter Set (Type 1617, Bruel & Kjaer Company), and Sound Intensity Analyzing System (Type 3360, Bruel & Kjaer Company) were used for the present study.

The experiment at the nursery was conducted between 11 : 00 A.M. and 14 : 00 P.M., on August 10, 1988, a sunny day with almost no winds were blowed. On the contrary, the tests in the Anechoic Chamber, were conducted on November 18, 1988. The injection of sound waves were repeated 3 times, and the mean values were used for the present discussions.

RESULTS AND DISCUSSIONS

Effects on noise attenuation by the hedge species of *Thuja orientalis* L. are shown in Tab. 1. The temperature and humidity of the testing sites were between 29-31 ℃ and 75-79 %, respectively.

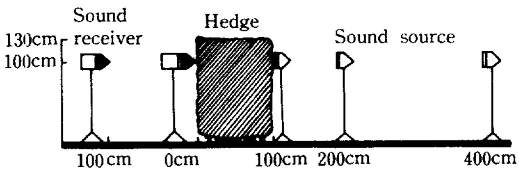

Fig. 1. Diagram of testing equipment for hedges.

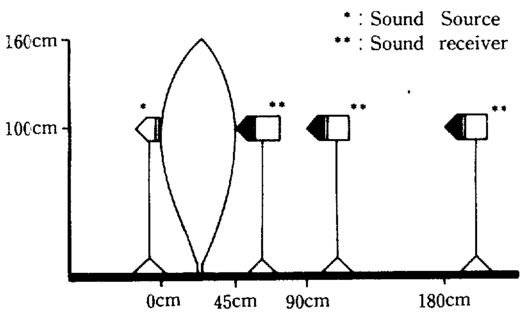

Fig. 2. Diagram of testing equipment for individual trees in the Semianechoic Chamber

At high frequencies such as 2,000 and 3,150 Hz., when the distance of the sound receiver from the hedge was 0 cm, the attenuation of the noise level was decreased as the distance increased. But the distance between the sound source and the sound receiver at 400 cm, which arranged with the distance of the sound receiver from hedge were placed at 0 and 100 cm, just backwards from the hedge(Tab. 1 and Fig. 1), showed relatively high noise attenuation effect at the low frequencies. It seemed to be the effect of ground waves. The vegetation covering the ground has an indirect effect on the ground condition and hence the attenuation rates at low frequencies(Fricke, 1984).

Effects of noise attenuation by the hedge species of *Euonymus japonicus* Thunb., which has more broader leaves than that of *Thuja orientalis* L., are shown in Tab 2. The sound levels were decreased as the distances increased between the distances of sound source and the sound receiver. But it showed an increased value, at low frequency, when the distance between the sound source and the sound receiver was 400 cm and the sound receiver was placed at 100 cm backwards from the hedge (Fig. 2). Theoretical and model work(Buellen & Fricke, 1982) suggested that the

Table 1. Effects of noise attenuation of *Thuja orientalis* L. between various positions of sound source and receiver

Distance microphone from hedge (cm)	Sound source (Hz)	Positions of the sound sources(cm) A (0) dB.	B (100) B.N.*	B (100) dB.	C (200) B.N.*	C (200) dB.	D (400) B.N.*	D (400) dB.	Attenuation rate(%) $\frac{A-B}{A}\times100$	$\frac{A-C}{A}\times100$	$\frac{A-D}{A}\times100$
0(Backwards from the hedge)	1,000	106.3	34.2	85.2	32.1	72.4	31.5	79.1	19.8	31.9	25.6
	2,000	101.1	33.1	84.0	31.2	82.3	31.1	65.8	16.9	18.6	34.9
	3,150	96.2	35.0	82.5	37.5	78.3	34.5	64.5	14.2	18.6	33.0
100 (〃)	1,000	106.3	31.9	81.9	34.3	72.9	30.8	77.9	23.0	31.4	26.7
	2,000	101.1	32.1	81.8	31.0	72.1	30.9	72.9	19.1	28.7	27.9
	3,150	96.2	36.4	79.2	35.6	72.0	36.4	67.6	17.7	25.2	29.7

*B.N. (dB.) means background noise, which is the noise in an environment from both near and far sources. Usually it refers to minimum levels when no strong sources of noise or sound are turned on (White, 1975).

Table 2. Effects of noise attenuation of *Euonymus japonicus* Thunb. at various positions of sound source and receiver

Distances of microphone from hedge (cm)	Sound source (Hz)	Positions of the sound sources(cm)							Attenuation rate(%)		
		A (0) dB.	B.N.*	B (100) dB.	B.N.*	C (200) dB.	B.N.*	D (400) dB.	$\frac{A-B}{A}\times 100$	$\frac{A-C}{A}\times 100$	$\frac{A-D}{A}\times 100$
0	1,000	106.3	32.3	89.1	32.5	82.5	35.6	79.1	16.2	22.4	25.6
	2,000	101.1	31.9	85.0	32.5	82.6	29.9	77.9	15.9	18.3	22.9
	3,150	96.2	37.6	78.6	37.1	74.3	37.5	73.6	18.3	22.8	23.5
100	1,000	106.3	27.1	83.6	33.7	72.9	30.6	79.8	21.4	31.4	24.9
	2,000	101.1	33.9	87.3	35.2	76.8	29.5	73.4	13.6	24.0	27.4
	3,150	96.2	36.5	81.1	35.2	72.8	34.1	67.8	15.7	24.3	27.4

* B.N. means background noise

Table 3. Effects of noise attenuation with and without tree, and attenuation rates which tested in the Semianechoic Chamber

	Hz	B.N.*	Positions of the sound sources(cm)				Attenuation rates(%)		
			A** (0)	B** (45)	C** (90)	D** (180)	$\frac{A-B}{A}\times 100$	$\frac{A-C}{A}\times 100$	$\frac{A-D}{A}\times 100$
Euonymus japonicus	1,000	12.0	106.3	92.3	84.4	80.0	13.2	20.6	24.7
	2,000	12.0	101.1	91.5	87.9	81.6	9.5	13.1	19.3
	3,150	12.0	96.2	90.3	84.8	79.4	6.1	11.9	17.5
Thuja orientalis	1,000	12.0	106.3	90.0	84.5	81.8	15.3	20.5	23.0
	2,000	12.0	101.1	90.1	86.0	78.9	10.9	14.9	22.0
	3,150	12.0	96.2	90.7	84.8	78.2	5.7	11.9	18.7
No trees	1,000	12.0	106.3	92.7	85.8	84.0	12.8	19.3	21.0
	2,000	12.0	101.1	91.4	88.3	80.9	9.6	12.7	20.0
	3,150	12.0	96.2	90.8	85.4	80.7	5.6	11.2	16.1

*B.N. means background noise
**Unit : dB.

direct effect of vegetation will be significant only at high frequencies. Thus, the present result go with this trends.

Effects of noise attenuation with and without trees, which tested in the Semianechoic Chamber, are shown in Tab. 3. All the level of noises were decreased as the distances increased. In the attenuation rates among *Thuja orientalis* L., *Euonymus japonicus* Thunb. and control (no trees), *Thuja orientalis* L. showed the most effective barriers in the attenuation rate of sound levels at almost all frequencies. Görk *et al* (1984) reported that a conifer species(*Abies pinsapo*) showed the highest rate of decreased sound level than that of the broad-leaved evergreen species (*Rosmarinus officinalis* and *Ligustrum vulgare*), and the present results showed trends similar to this.

Thus, in the widest sense, trees do control noise levels. They appear to maintain ground conditions, create a micro-climate, give a psycho-physical benefit and contribute to high frequency attenuation rates (Fricke, 1984).

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