PERFORMANCE OF HEDGES AND THEIR CHARACTERISTICS FOR BUFFERING NOISE IN URBAN RESIDENTIAL AREAS

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ABSTRACT

Many environmental designers are currently searching for better solution on reducing noise frequency levels in housing estates. Planting hedges as buffer is commonly done but the question is whether they serve the right function and purpose. In order to determine the plant performance, a sound level meter was used to detect noise reduction from commonly planted hedges in residential areas of Putrajaya and Kuala Lumpur. The source of sound for measurement was from a grass trimmer that is commonly heard in residential areas. This paper highlights the performance of selected local plants in absorbing the noise frequency. A statistical analysis showed that hedges such as Baphia nitida and Bixa orellana of sufficient heights and length are promising and have good potential in controlling sound levels. Ixora 'sunkist' with small leaves and with more layers of planting also provides similar result. Until a controlled experimental study is carried out, this initial finding would be useful in plant selection for buffering noise in local landscape projects.

Keywords: *Sound Level, Buffer, Noise Reduction, Hedges, Plant Characteristics*

1. INTRODUCTION

In Malaysia, noise from continuous usage of a grass trimmer in residential areas and parks has now become a public concern. Recently, some stakeholders, professionals and general public in a Workshop on Public Parks organized by the National Landscape Department in Kuala Lumpur have identified noise from the grass trimmer as one of the serious environmental pollutants. This shows that consideration of noise and sound elements in urban areas is absolutely important in our daily life today.

Like air pollution, the effect of noise from vehicles has been noted to increase to the point of threatening happiness and health. Vern Knudsen (1967) said that noise is one of the chief drawbacks to the enjoyment of modern urban living, and Abdullah (2006) emphasized that noise pollution absolutely reduces the quality and productivity of human life, causes stress and tension as well as triggers social problem. Noise has an important environmental impact with short and long-range effects on human communities and on wildlife (Carlos et al.,1957; Marquis-Favre et al., 2005).

The design of a comfortable environment through landscaping has been tremendously improved in recent years particularly in urban areas. Majority of urban residential areas have been planted with shrubs and hedges to be marked as a boundary as well as to reduce noise level from the nearby traffic. Robinette (1972) found that plants are effective in screening sound levels sensitive to human ears, while variability of a sound level contributes to its annoyance values (Latshaw, 1973).

Many earlier studies have only examined tree belts of particular species (Embleton, 1963; Kraght, 1979 and 1981) but failed to discuss noise reduction effect in relation to branching, foliage, and height. Heimann (2003)

demonstrated that direct attenuation by trunk (produced by multiple reflections and scattering) is much larger than indirect attenuation which is due to reduction of the vertical wind gradient in the stand. Other statement from Embleton (1972, p.122) is that branches are capable of acoustic respond rather than twigs, needles or leaves. However, according to Martens (1981), different parts of vegetation, i.e. the soil surface, the trunks, stems, and branches of trees, foliage of herbs, shrubs and trees, and the air in the vegetation all contribute to the overall acoustic climate of each plant community.

Therefore, a fundamental study was carried out to determine the performance of a few common hedge species and to examine the plants characteristics in buffering noise in our environment. The purpose of the study was to identify local species that could be utilized effectively in controlling sound levels for urban areas so that plants selection and their usage could be more functional, economical and most importantly beneficial for the purpose.

Most hedges in the study area had been planted as sound barrier or as site demarcation. Although the idea for the planting was good, nevertheless, the technical aspects and the acoustic performance of those local plantings had not been studied adequately to determine their efficiency. Plants were selected mainly based on their aesthetic values, availability and probably their growth habit. Information on the relative effectiveness of local plants in controlling sound is rarely available for our consumption such as the one carried out by Robinette in 1972. Therefore, this study would help to identify the performance and characteristics of selected local plants in absorbing the noise frequency.

This paper highlights how the investigation was conducted in the field where commonly found hedges in the area of Putrajaya and Kuala Lumpur were selected and tested for their efficiencies in reducing sound. The details of experimental design are described and the results are discussed in the appropriate sections. The paper concludes with discussion on the potential plants characteristics that need to be considered when planting for noise reduction as well as the prospects of using suitable plant materials in landscape development and planning for urban residential areas.

2. METHODOLOGY

2.1 Materials

Six species of hedges (see Table 1) that are commonly being planted in Precinct 10 Putrajaya and Sri Petaling Kuala Lumpur were being studied. These species were selected based on the location and function of planting, i.e. located within the housing area as border plantings. Experiments to test their performance in reducing noise level were carried out on dry days when there was no rainfall, the temperature ranged between 27-30 degree Celsius, and the wind speed was between 5-15k km/hour. The species and the characteristics of the hedges are given in Table 1.

Table 1: Characteristics of Hedges Used in the Study

No.Species	*Hedges Condition*					
	Height (m)	*Length (m)*	*Layer*	*Planting Distance (m)*	*Density (per sq.m)*	*Tree Arrangement*
1. Hibiscus rosa sinensis	1	5	2	0.2	10	linear
	1	40	1	0.5	2	linear
2. Eugenia oleracea	1.6	43.5	1	0.5	2	linear
3. Acalypha chenensis	1.6	32	2	0.3	6.7	alternate
4. Ixora 'sunkist'	0.9	21.5	3	0.35	8.6	alternate
5. Baphia nitida	17.5	106	2	0.2	10	alternate
	6	30	1	0.6	1.6	linear
6. Bixa orellana	5	30	1	0.6	1.7	linear

2.2 Noise Source

A portable motorized grass trimmer (Mitsubishi 33CL) was used due to its ability to produce noise consistently and was the sound source commonly heard in the housing area. In this study, a motorized grass trimmer was turned on at a consistent sound pressure level (80-83 dB) for 2 minutes at each experiment point and readings were taken using Quest sound level meter.

2.3 Experimental Design

The measuring instrument, which was represented by Quest sound level meter, was located at three-location points along the hedges belt. Since the length of each species was different according to its location and purposes of planting, sound pressure levels were measured at 3 points along two transect lines at each hedge belt. Both transect lines were marked 2-5 meters from the starting and finishing of the hedges belt.

At each three-location point, the noise source (grass trimmer) was turned on in a consistent noise pressure level at the wayside road where the sound level meter was placed and readings were taken 1, 2 and 3 meters from the edge of hedges of the house building area, within the house boundary (Figure 1). Control test run was set up in open ground near the hedges belts that were being experimented in order to compare the difference in sound pressure levels between the hedges belts and open ground.

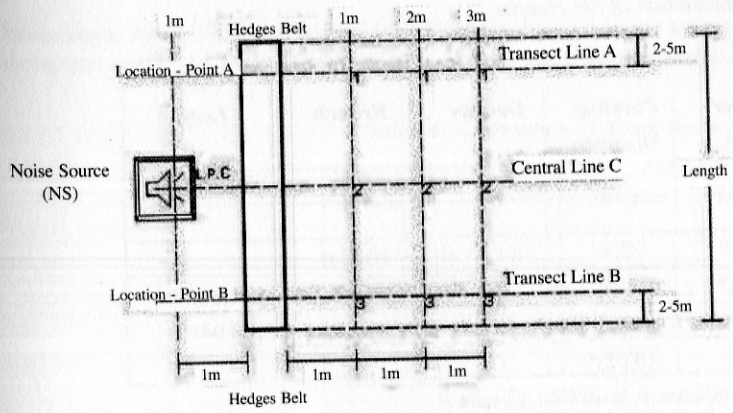

Figure 1: The experimental design.

2.4 Acoustic Measurement

The experiment was conducted in August 2007 at the area of Sri Petaling, Kuala Lumpur and Precinct 10, Putrajaya. The noise source (grass trimmer – Mitsubishi CL) was placed at each location point within 2 transect lines at 1 meter from the edge of the hedge belt and was carried on the back of a worker 1.2 meters from the ground (Figure 2). The sound level meter was operated for 2-5 minutes before the final measurement was taken at 1.2 meters above the ground at each measuring point and facing the noise ***source*** (Figure 2). The sound level meter was calibrated at 94dB (i.e. the level specified by the manufacturer so as not to cause overload) before being used and set up.

2.5 Data Statistical and Analysis

From the result, performance of six species of hedges in reducing noise was determined. Multi-regression was carried out to evaluate the characteristic of 6 hedges that contributed to noise reduction. In this model, the dependent factor was the noise reduction and the independent factors were height, branches, and leaves of hedges.

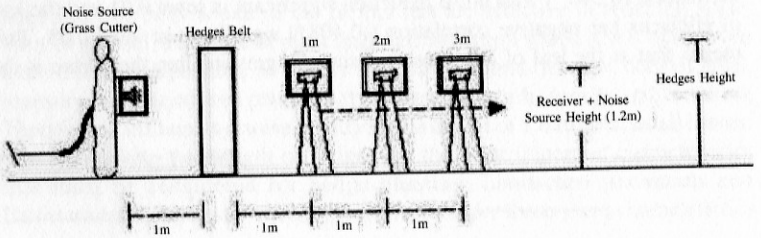

Figure 2: The profile of experimental design.

3. RESULT

3.1 Reduction of Noise by the Hedges

The level of noise reduction of 6 hedges at 1 meter distant from the noise source is shown in Table 2.

Based on Kolmogrov test all data are normal (á>0.05) except for Eugenia oleracea. The percentage reduction of noise level at various measuring distances of the six different hedges varies. As shown in Table 2, the largest percentage of noise reduction is from Ixora 'sunkist', followed by Baphia nitida, Bixa orellana and Acalypha chinensis. Despite the higher percentage, we have to bear in mind that Ixora was planted in 3 layers as compared to Acalypha in 2 layers while Baphia and Bixa were planted in single layer. Nevertheless, the percentage of noise reduction by Baphia nitida is higher than Bixa orellana.

3.2 Relationship of Plants Characteristics and Noise Reduction

Multi regression analysis was carried out to evaluate the characteristics of 6 hedges that contributed to noise reduction. Relationship of plants characteristic and their noise reduction (Table 3) indicated that both heights (0.624**) and length (0.663**) had significant positive correlation at 0.01 (2-tailed). This means the noise reduction is greater when the hedge planting is taller and longer.

Meanwhile, relationship of noise reduction with plants characteristics based on species (Table 4) indicated that Hibiscus rosa sinensis have positive correlation (0.540**) with noise reduction significant at level 0.01 and the leaf of Hibiscus has negative correlation (-0.408*) significant at level 0.05. This means that as the leaf of Hibiscus rosa sinensis gets smaller, the higher is the noise reduction.

Table 3: Relationship of Plant Characteristics and Noise Reduction

Characteristic	*dB reduction*
Height	0.624**
Branch	0.321
Leaf	-0.199
Density	0.346
Length	0.663**

* Correlation significant at 0.05 level (2-tailed)
** Correlation significant at 0.01 level (2-tailed)

Furthermore, the leaves of Ixora Sunkist are positively correlated (0.802**) with noise reduction and this means the smaller the leaves, the higher is the noise reduction. The branches of Ixora Sunkist and Acalypha chinensis are negatively correlated (- 0.655**) and this means the less dense is the branching, the lesser is the noise reduction at level 0.01. As for Baphia nitida, the shorter the planting and the bigger is the size of leaves, the lesser will be the noise reduction.

Table 2: Percentage of Noise Reduction of Six Hedges

No.Species	*dB Reduction*	*Height (m)*	*Length (m)*	*Layer (m)*	*Planting Distance*	*Density*	*Branch*	*Leaf*
1. Hibiscus rosa sinensis	(0.06)*							(0.048)*
2. Eugenia oleracea	(0.27)*							
3. Acalypha chenensis							(0.01)*	
4. Ixora 'sunkist'				(0.00)**			(0.01)**	(0.01)**
5. Baphia nitida		(0.00)**	(0.01)**					(0.04)**
6. Bixa orellana					(0.02)*			

* Correlation significant at level 0.05 (2-tailed) ** Correlation significant at level 0.01 (2-tailed)

4. DISCUSSION

From the six species of hedges studied, Baphia and Bixa had the highest percentage of noise reduction i.e. approximately 7.9dB and 7.46dB respectively despite being planted in a single layer. There is a possibility that Ixora 'sunkist' would provide similar percentage of noise reduction if it was planted in a single layer as Baphia and Bixa due to its smaller leaf sizes as can be seen from the result in Table 4. There are relationships between various plant characteristics such as branch, height, leaves and length of hedges. This means these characteristics of hedges can reduce noise. However this is not in agreement with Cooke and Haverbeke (1974) where density, height, length and width of tree belts are the most effective factors in reducing noise rather than leaf size and branching characteristic, while Aylor (1972) stated that density, height, length, and width diffuse noise.

The contradiction for this result is because this study used only shrub hedges and the previous study used tree belts. Another explanation for this was due to the insufficient height of the hedges i.e. 0.9 meter and 1.6 meters except for Baphia and Bixa and causing the sound waves to refract from the top of the barrier (hedges), hence the noise reduction decreases. There was a correlation between heights and noise reduction (0.624^{**}). This means the higher the shrub the more noise is being reduced. This result is in agreement with Cooke and Haverbeke (1974) where height of tree belts is the most effective factor in reducing noise. Therefore, low hedges are ineffective and inefficient in noise reduction (Ishii, 1994 in Fang and Ling, 2003).

According to Aylor (1972) that branching and leaf characteristics have resonant absorption quality. In Table 4 Hibiscus rosa sinensis has positive correlation (0.540^{**}) with sound reduction at significant level 0.01 and the leaves of hibiscus have negative correlation (-0.408^{*}) and significant at 0.05 level. This means that as the leaf of Hibiscus rosa sinensis gets bigger the less is the noise reduction. Meanwhile the leaves of Ixora 'sunkist' have positive correlation (0.802^{**}) with sound reduction which means that as the leaf of Ixora gets smaller, the higher is the noise reduction. This result indicates that small leaves can effectively reduce noise.

In addition, the branches of Ixora 'sunkist' and Acalypha chinensis have negative correlation (-0.655^{**}) with noise reduction, and this means that as the branching of Ixora 'sunkist' and Acalypha chinensis becomes more dense the less is the noise reduction. The result indicates that dense branching is not contributing towards noise reduction because branching has resonant absorption capability. This is due to the high degree of flexibility and vibration properties of the plants. Generally, with sufficient height, hedges of Ixora 'sunkist' would provide the best noise reduction effect. In addition, height, width or number of layers of planting also contribute to significant noise reduction factor. Greater width resulted in higher absorption and diffusion (Cooke and Haverbeke, 1974 in Fang and Ling, 2003), and this is true looking at the performance of Ixora. Fang and Ling (2003) also pointed out that the length of tree belts is one of the factors that are effective in reducing noise. Thus in general, the usage of plant materials to control sound levels has proven quite effective depending on factors such as the sound (its type, decibel level, intensity and origin), and plantings (type, height, length, density and location). Therefore in influencing noise reduction, the height of 1.6 meters, small leaves, dense branching and length of hedges are the most important characteristics that must be considered for hedge planting. Landscape Architects and Environmental Designers should therefore consider those plant characteristics

Table 4: Correlation of Noise Reduction of Plant Characteristic Based on Species

Species	*Height*	*Branch*	*Leaf*	*Density*	*Length*	*dB Reduction*
Hibiscus rosa sinensis	0.362	0.333	-0.408*	-0.107	0.322	0.540**
Eugenia oleracea	0.194	0.218	0.267	0.346	-0.068	0.231
Acalypha chinensis	0.194	-0.655**	0.267	-0.143	0.088	-0.185
Ixora 'sunkist'	0.244	-0.655**	0.802**	-0.341	0.231	-0.235
Baphia nitida	-0.807**	0.333	-0.408*	-0.076	-0.613**	-0.314
Bixa orellana	-0.048	0.218	-0.267	0.377	0.116	-0.107

* Correlation significant at level 0.05 level (2-tailed)
** Correlation significant at level 0.01 level (2-tailed)

when selecting plant materials as noise buffers in their projects so that their designs could be more efficient and functional.

As a conclusion, some of our local plants have the potential to screen out sounds in the urban environment. In general, the performance of Baphia nitida, Bixa orellana, Acalypha chinensis and Ixora 'sunkist' are promising in controlling sound levels if sufficient height, length and width of plantings are used. Nevertheless, hedges like Hibiscus and Eugenia could carry the same function of noise reduction on the condition that more layers and longer plantings are enforced. Here, due to the uncontrolled environment of the study area, it is not possible to provide a conclusive result unless an experimental study in a controlled environment is carried out. Generally as an initial finding to determine the best noise reduction performance of local shrubs, they should be planted at an optimum height, length, as well as width or number of layers.

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