Effect of Architectural Tree Model to the Noise Level of Motor Vehicle on Demang Lebar Daun Street Palembang

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ABSTRAK

Telah dilakukan penelitian pengaruh model arsitektur pohon terhadap tingkat kebisingan suara kendaraan bermotor di jalan Demang Lebar Daun Palembang. Tujuan dari penelitian ini adalah menganalisis model arsitektur pohon yang dapat mereduksi tingkat kebisingan paling tinggi di antara model arsitektur pohon yang dijumpai dan mengidentifikasi model arsitektur pohon. Metode yang digunakan adalah *purposive sampling.* Pengukuran tingkat kebisingan dan model arsitektur dipilih sesuai dengan jenis pohon yang dijumpai di sebelah kiri atau kanan jalan. Pengukuran tingkat kebisingan siang hari dilakukan secara bersamaan pada titik 1 meter di depan pohon, 1 dan 5 meter di belakang pohon, selama 10 menit dengan pembacaan setiap 5 detik pada pukul 07.00, 10.00, 15.00 dan 20.00. Hasil penelitian menunjukkan bahwa model arsitektur pohon *Switenia magahoni* adalah model Rauh, pohon *Lagerstroemia* sp. adalah model Troll dan pohon *Thyrsostachys siamensis* adalah model McClure. Reduksi tingkat kebisingan tertinggi oleh pohon bambu, masing-masing 4,88 dB(A) dan 8,52 dB(A) pada jarak 1 meter dan 5 meter.

Kata kunci : Tingkat kebisingan, Reduksi, Model arsitektur pohon

ABSTRACT

The research on the effect of architectural tree model to the noise level of motor vehicles on Demang Lebar Daun Street Palembang has been conducted. The purpose of this study was to analyze kind of architectural tree model can reduce the highest noise levels among the architectural tree models encountered and identify the architectural tree model. The method used was purposive sampling. Measurement of the noise level and architectural models were selected according to the type of the tree encountered on the left or right side of the street. The noise level measurement during the daylight was carried out simultaneously at a point of 1 meter in front of the tree, 1 and 5 meters behind the tree,for 10 minutes with the readings for every 5 seconds at 07:00, 10:00, 15:00 and 20:00. The results showed that The architectural model of *Switenia magahoni* tree was Rauh model, *Lagerstroemia* sp. tree was Troll model and *Thyrsostachys siamensis* tree was McClure model. The highest noise level reduction was from bamboo tree, respectively by 4,88 dB (A) and 8,52 dB (A) at the distances of 1 and 5 m.

Keywords: noise level, reduction, architectural tree model

INTRODUCTION

Palembang city urban environment, especially Demang Lebar Daun Street develop economically with the increasing of infrastructure growth, such as housing, shops, shopping centers and highways. Unfortunately, this is not accompanied by the maximal construction of ecological environment, such as the availability of green open space, urban forest, play ground, as well as various types of plants grown throughout the region.

In addition, large number of motor vehicles passing the road, either motor vehicles within or outside the city that enter the territory of Palembang city. This road also connects several areas of the District/Sub-District and other national roads in Palembang city. This further exacerbates the urban living environment such as temperature increament, air pollution such as dust, even the sound or noise pollution caused by the activity of the motor vehicle. The traffic noise comes from the sound of motor vehicles, particularly from the vehicle's engine, exhaust, horn, as well as the interaction between the wheels to the road.

Along the roadside of this road with a certain distance from its median is planted with various combination of trees; shrubs and bushes, close leaves mass/thick leaves, there are variations in the canopy vertically, and are combined with sound absorber wall. These trees planting have many purposes including as urban aesthetics, protection from the sun, reducing noise and dust, as the urban forest and so forth.

One of the effort to control the noise is controlling the propagation medium between the source and receiver of the noise, with the principle of weaken noise intensity that propagates from the source to the receiver. By creating the obstacles, such as trees or plants vegetation as a barrier to reduce the noise. According to Heryanto (2004), noise control of the propagation medium can be done in two ways, namely outdoor and indoor propagation control. Special for outdoor propagation control such as noise reduction by air absorption, climatic conditions, vegetation, and reduction by barrier.

According to Werdiningsih (2007), the use of hedgerow is highly appropriate for buildings located at dense urban areas and passed by traffic, because it can be dust, pollution and noise barriers. Hedgerows in urban environments serve as environment anticipation such as noise filter from the traffic noise and air pollution filters. According to Kalansuriya et al. (2009), a good planning and vegetation planting on the roadside can reduce the impact of the highway noise. The width of the vegetation as a barrier is directly proportional to the amount of sound absorption.

Trees planted along Demang Lebar Daun Street Palembang have architectural tree model, rootstock branch height, and the height and width of canopy. According to Hallé et al. (1978), an architectural tree model is a tree building construction as a result of the growth pattern of meristematic that is morphogenetically controlled. The elements of a tree architecture consists of a pattern of stem growth, branching and the formation of terminal crest. Generally there are 23 models of tree architecture model; Holtum, Corner, Tomlinson, Schout, Chamberlain, McClure, Leeuwenberg, Koriba, Prevost, Fagerlind, Petit, Nozeran, Aubreville, Massart, Roux, Cook, Scarrone, Stone, Rauh, Attim, Mangenot , Champagnat, and Troll models.

RESEARCH METODOLOGY

Place and Time

The research was conducted in Demang Lebar Daun Steer Palembang. The research period was divided into two steps; i) preliminary survey that was carried out in August 2015, and ii) measurement of the noise level, rootstock branch height, height and width of the tree canopy was conducted in February until March 2016.

Instrument

The instruments used in this research were sound level meter, 50 m long roller meter, Suunto-type clinometer, and stopwatch.

Method

The method used in this research was purposive sampling where the measurement of the noise level was selected according to the type of the tree encountered on the research location. Noise level measurement was done on the left or right side of the road before and after passing through the trees, which were carried out simultaneously. Then followed at several different points with similar type and model of the architectural tree models.

Identification of Architectural Tree Model

Basic observations of the architectural tree were the characteristic of the trunk, branching patterns, differentiation and reiteration of branches canopy shape. Descriptions of each type of tree that has been established in research checked against the existing literature, the model has been described by Halle and Oldeman (1970) and matched with several previous studies. Then an architectural model of the type of tree is set represent or resemble a most suitable model of 23 models that have been described (Halle et al., 1978).

Measurement of Rootstock Branch Height, Height and Width of Tree Canopy

The measurement of rootstock branch height and canopy height was done using Suunto-type clinometer by tangen method (Larjavaara and Muller-Landau, 2013). Meanwhile, the width of tree canopy was measured on the longest and widest canopy (Wijayanto dan Rosita, 2012).

NoiseLevel Measurement (SNI 19-7119.9-2005 and KEP. MENLH, 1996)

Noise level measurement was simply done by using sound level meter for 10 (ten) minutes for every measurement and the readings were done for every 5 (five) seconds, the measurement time was done during 16 hours activity during the daytime (KEP. MENLH, 1996). Sound level meter was located at 1 meter in front of the tree and behind the tree at distance of 1 and 5 meters, as well as at a height of 1.5 m above the ground (Tyagi et al., 2013), as presented in this figure below:

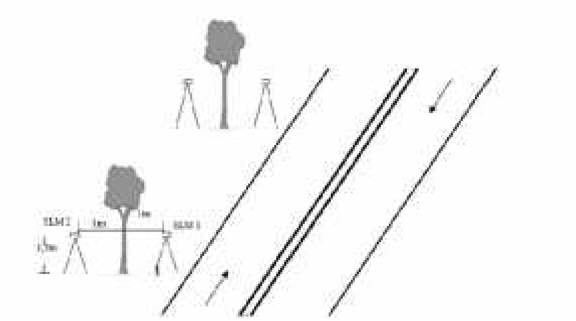

Figure 1. Sketch of noise level measurement on highway

RESULT AND DISCUSSION

Identification of Architectural Tree Model

Swietania magahoni Tree

The development of main stem monopodial orthotropicand grow indefinitely. While the monopodial branching, orthotropic growth (part of the leaf bud or twig ends facing up) and rhythmic. The leaf stalk arranged helically in every branch with a perpendicular direction to the branches, each leaf on a stalk arranged facing each other, the leaf blade rounded oval and flowers or fruit arranged laterally.

Rauh model is an architecture tree model with the orthotropic growth trunks indefinitely, rhythmic and politaksis spiral. Orthotropic branching and reiterationat the next branching (Veillon, 1981). From the research of Hasanuddin (2013), Rauh model is an architecture tree model that has a characteristic of tree monopodium orthotrop trunk. Rhythmic growth caused the branches arranged in a bouquet, the branch is also orthotrop, and axes can be grown indefinitely. Example of the tree with this model is *Swietania magahoni*.

Lagerstroemia sp. Tree

Lagerstroemia sp. tree with simpodial main stem, plagiotropic stem growth. Monopodial and plagiotropic branching (branch growth is leading to the side and end of the buds facing sideways or droop downwards). Continuous branching (branches grow on the main stem, followed by other branches). The leaves are arranged opposite each other, short-stemmed leaves, large leaves and stiff, and the terminal flowering. At the distal part of each axis there are branches with or without determination of growth (bud).

According to Sulasmini et al. (2007), *Lagerstroemia* sp. plant has short-stemmed and thick leaves, with elongated elliptical shape, dark green color and conus canopy shape. This is in line with the research done by Hasanuddin (2013), Troll model is an architectural tree model with simpodium rod character. All axes point plagiotrop from early. The flowering tree after mature, the leaves tend to be confronted. The first axis is ortrotop, next axes begin to differentiate into the horizontal direction gradually and flowering tree as grown. Upright rod formation occurred after the leaves fall. So *Lagerstroemia* sp. tree resemble the architectural tree model described by Halle et al. (1978), with Troll model.

Thyrsostachys siamensis Tree

Thyrsostachys siamensis trees have monopodial main stem and orthotropic growth, shady plagiotropic twigs branch. Mixed stem axis, the trunks of trees grow out of the ground to form clumps. Plagiotropic branching / leafy twigs until the branches, twigs and leaves will dangle near and even down to the ground. *Thyrsostachys siamensis* leaves are small, elongated and elastic (resilient). These resemble an architectural tree model described by Hallé et al., (1978), so *Thyrsostachys siamensis* is categorized as a McClure architectural tree model.

Noise Level Reduction

The result on the average noise level during the daytime at Demang Lebar Daun Street Palembang by the *Swietania magahoni*, *Lagerstroemia* sp., and *Thyrsostachys siamensis* trees at the distance of 1 and 5 meters behind the trees are presented in Table 1.

Table 1. Average noise level reduction analysis during daytime at the distance of 1 and 5 meters by the *Swietania magahoni*, *Lagerstroemia* sp., and *Thyrsostachys siamensis* trees

Tree	Average H_{RB}	Average H_C	Average W_C	Noise level reduction			
				1m behind the trees		5m behind the trees	
				dB(A)	%	dB(A)	%
Swietania magahoni	2,16	9,40	8,24	2,61 ± 1,35	3,5	6,00 ± 1,32	8,2
Lagerstroemia sp.	1,16	7,01	7,38	2,64 ± 0,75	3,6	6,89 ± 1,20	9,4
Thyrsostachys siamensis	0,93	4,26	4,77	4,88 ± 3,15	7,0	8,52 ± 1,86	11,9

Notes:H_{RB} : rootstock branch height, H_C : canopy height, W_C : canopy width

The results showed that the noise level reduction of motor vehicles at Demang Lebar Daun Street Palembang by *Switenia magahoni* trees was 2,61 dB (A) or 3,5% at a distance of 1 meter behind the tree and 6,00 dB (A) or 8, 2% at a distance of 5 meters behind the tree. Reduction of the noise level by *Lagerstroemia* sp. trees was 2,64 dB (A) or 3,6% at a distance of 1 meter behind the tree and 6,89 dB (A) or 9,4% at a distance of 5 meters behind the tree. Meanwhile, the noise level reduction by *Thyrsostachys siamensis* trees was 4,88 dB (A) or 7% at a distance of 1 meter behind the tree and 8,52 dB (A) or 11,9% at a distance of 5 meters behind the tree.

The big difference in the magnitude of noise level reduction by the *Swietania magahoni*, *Lagerstroemia* sp., and *Thyrsostachys siamensis* trees was due to the differences in the reflection, refraction, dispersion and absorption processes of sound by the trunk, branches, twigs and leaves by each tree. *Switenia magahoni* tree has a monopodial main stem, orthotropic branches growth, spiral leaf stalk arrangement for both the first and the next branches, small leaves and direction of leaf stalks tends to the horizontal direction perpendicular to the direction of the branch.

In the *Switenia magahoni* trees, a space is formed between the branches, the leaves on one branch, and a space formed by the leaves from one branch with another. So the incoming noise will undergo reflection, refraction, dispersion and absorption by the trunk, branches, twigs and leaves. However, due to the space formed and parallel incoming sound waves to the leaf, some voice will directly penetrate or forwarded to a recipient behind the tree.

Lagerstroemia sp. tree has simpodial main stem, plagiotropic branches growth, wide and rigid leaves, and leaf arrangement tends to face and dangle downward. This kind of leaves will cause reflection and dispersion of incoming noise into the leaf surface. Sound wave scattering will cause the propagation of the wave energy that leave the direction of propagation between the sound source and the receiver. So that the wave energy received by the receiver will be smaller.

Meanwhile in *Lagerstroemia* sp. trees, there are spaces between the branches, the leaves on one branch, and the space formed by the leaves from one branch to another branch. The reflection and refraction processes of the sound done by the trunks and branches are more prevalent, because of the simpodial stem and plagiotropic branches resulting in a gap between one branch with another. Canopy shape of *Lagerstroemia* sp. tree resembles conus which will cause the sound absorption. However, the density of the leaves have a significant role in absorbing sound. Nevertheless, some voices still be forwarded to the recipient behind the tree through the space formed by both the leaves and branches.

This is in line with the research by Widagdo (1998), where the space between the leaves allow sound to penetrate into the vegetation and then pass to the back of vegetation. Sound energy strike the vegetation, and then reflected, absorbed, dispersed, deflected or forwarded by the leaves as sound barrier on vegetation. Reflection, absorption, deflection, or continuation of sound are influenced by leaf thickness, density, leaf angle in the direction of the sound energy coming, and position among the leaves.

Thyrsostachys siamensis trees have monopodial trunks with orthotropic growth, the rod axis are mixed and form clumps from the ground, plagiotropic leafy branches and dangled close to the ground, small leaves, elongated and elastic. *Thyrsostachys siamensis* clumps are arranged by some *Thyrsostachys siamensis* trees that produce slit arrangements. Incoming sound waves at *Thyrsostachys siamensis* clumps will undergo reflection, and refraction processes by the first rod, while the refracted sound will be reflected or refractied by another rods and so on, then go out leaving the clumps of *Thyrsostachys* *siamensis* toward the receiver. So that the energy sound waves arrive at the receiver behind the tree will be smaller.

This is consistent with the theory that the noise level reduction occurs due to the sound waves encounter the barrier will undergo reflection, refraction, scattering and absorption. When a sound wave strikes a hard surface, rigid and flat, then almost all of the sound waves are reflected.

Thyrsostachys siamensis leaves are small, elongated and elastic that allow the reflection, refraction, and dispersion of incoming noise to be occurred (sound leaving the direction of propagation between the sound source and the receiver). While the exuberance of a dense *Thyrsostachys siamensis* leaves will cause a big enough sound absorption, although there is still space formed between leaves that allow most of the noise are forwarded to the receiver.

Leaves of the plant can absorb acoustic energy by transferring the kinetic energy of the air vibration pattern to vibration patterns on the leaves. Therefore, the acoustic vibration energy and most of the energy is lost to be heat energy due to the leaves friction (Aparicio and Surez, 1993). Role of tree branches and leaves as a barrier can reflect, refract, scatter and absorb sound waves (Maleki and Hosseini, 2011).

The use of perforated barrier but covered by trees can reduce noise, because the incoming sound will be refracted and absorbed first by the leaves, stems and twigs, and some will be reflected back toward the sound source and the rest will be forwarded to the receiver (Kusuma et al. , 2003).

This is in line with Nilsson et al. (2015), that the absorption of sound waves caused by sound waves lose some of its energy to make the leaf vibrated (leaf follow the harmonic oscillations). Some of the vibration will be damped, because the leaf is connected to other stiff parts of the plant. As a result, most of the energy of sound waves effectively dissipate through the heat transfer (most of the wave energy is lost / absorbed by the leaves that turns into another form of energy). So that the sound wave energy received by the receiver becomes smaller.

CONCLUSION AND SUGGESTION

Based on the results and discussion above, it can be concluded that:

1. Architectural tree model of *Switenia magahoni* tree is Rauh model, meanwhile *Lagerstroemia* sp. tree is Troll model and *Thyrsostachys siamensis* tree is included in McClure model.
2. *Thyrsostachys siamensis* tree with McClure model reduces noise level the highest by 4,48 dB (A) or 7% at a distance of 1 meter behind the tree and 8,52 dB (A) or 11,9% at a distance of 5 meters behind the tree.

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