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EFFECT OF VEGETATION COMPOSITION ON NOISE AND TEMPERATURE IN WARU - SIDOARJO HIGHWAY, EAST JAVA, INDONESIA

Utami Retno PUDJOWATI[1,2*], Bagyo YANUWIADI[1,3], Rudy SULISTIONO[1.4], Suyadi SUYADI[1]

[1] Environmental Science and Technology Graduate Program, University of Brawijaya, Indonesia
[2] Department of Civil Engineering, State Polytechnics of Malang, Indonesia
[3] Department of Biology, Faculty of Mathematics and Natural Science, University of Brawijaya, Indonesia
[4] Department of Agroecotechnology, Faculty of Agriculture, University of Brawijaya, Indonesia

Abstract

The city development and population density need to be followed by infrastructure and facilities such as residential facilities, education, and transportation industries. Infrastructure development has a tendency to minimize the green open space. This region decreased could result in noise and temperature rise due to the increasing amount of residential development, the number of motor vehicles and industrial and transportation using fossil fuels in its production process. It could be mitigated by planting along highway. Naturally, the vegetation could reduce noise and temperature. Vegetation Composition existing along the highway Waru-Sidoarjo are tree-shrub-bushes composition, no vegetation at all composition, just tree composition and tree-shrubs composition. This study aimed to compare the percentage of noise reduction and a decrease in the temperature of each vegetation composition existing along the highway. The results of this study showed that vegetation composition which is consist of trees, shrubs and bushes was more effective to reduce the noise (up to 12.25%) and to decrease temperatures (up to 8.18%). It's recommended for Waru-Sidoarjo highway management to plant the tree-shrub-bushes vegetation composition for reduced the noise that occurs along the highway and helped temperature decrease, for the convenience of road users.

Keywords: *vegetation composition; noise reduction; temperature decrease.*

Introduction

Temperature is an inherent characteristic, possessed by an object which is associated with heat and energy. The air temperature will be changed markedly over a period of 24 hours. Climate change is closely related to the energy exchange process takes place in the atmosphere. Energy absorption of sunlight will result in increased air temperature. Maximum daily air temperature is reached sometime after the maximum light intensity during the light beam falls perpendicular at noon. Most radiation reflected from the earth's surface will also be absorbed by gases and atmospheric particles. Because the density of air near the surface is higher, otherwise at night higher and more opportunity to absorb the radiation reflected from the Earth's surface, the daytime air temperature near the surface will be higher than on the higher air layers,

[*] Corresponding author: utamithe1st@gmail.com

whereas at night, especially before dawn, when the air temperature near the surface will be lower than the air temperature at the higher air layers [1]. In the daytime with sunny weather conditions, high temperatures will be received from the sun which will result in expansion of air. In the atmosphere is expected to be a decrease in temperature and pressure in accordance with high gain. Ambient air and the adiabatic lapse rate affect the formation of atmospheric stability. When the temperature is set higher than the surrounding air, the air density is moving up at a speed that is lower, will be smaller than the density of the surrounding air, so the air will be re-stabilized [2].

The tall buildings that withstand heat radiation, especially at night, the use of heat storage materials such as asphalt and cement, lack of vegetation or plants, made temperature increasing in the urban areas. Tall buildings can block the movement of the wind, the tall buildings that block the wind speed rate. In the big city air circulation is unstable, and move up. Wind that moves up will bring particles such as pollutants, dust, fumes and so forth. These particles act as anti-condensation. Glass-walled building will also emit heat radiation from the sun, so that the area around this building will increase the temperature. Transportation is a good movement of people and goods from one place of origin to a destination. On the move, always use a form of transportation vehicles in operation cause noises like the sound of the engine and the exhaust out through this level. These voices could be tolerated that the consequences thereof would not constitute a nuisance, but at a higher noise level generated by the vehicle is called noise pollution [3]. Increased levels of noisy outer space are determined by: a) the state of the sound source (frequency, location, composition, whether a line or point), b) a state of nature and vegetation through which the sound; c) the state of the atmosphere, such as wind speed and direction, air temperature, and humidity. With the wind blowing from the sound source to a point, then the point will receive sound faster, and in greater strength. On the contrary, when the wind is blowing towards the opposite direction, away from the point, then the point will receive a sound with a weaker strength.

Air in the sound wave propagation medium and small power absorb some of the sound waves that pass through it. The ability of the air absorption depends on temperature and humidity. Greater uptake will occur in low-temperature air compared with high-temperature air. In the low-temperature air, more stable molecules and meeting so that the friction that occurs when sound waves propagate into greater strength will thus decrease. The sound will travel faster in air at high temperature because the molecule was more tenuous and the sound can propagate with minimal obstruction [4]. Plants can not only taken advantage of the physical results production of parts of the plant, but the plant also acts as a role in creating comfort, aesthetic form and reduce pollution. These pollutions were formed of thermal energy or radiation, and noise. The plants were able to absorb several types of pollutants effectively, so it can act as a role in cleaning the atmosphere of pollutants.

Some of the elements that affect the temperature at the earth's surface horizontally, among others: a) lies the latitude of a place; b) air temperature in the atmosphere was varied according to altitude location. Temperature up to a certain height can be decreased, but according to the height of the other increases. In the troposphere layer (bottom layer atmospheric) air temperature decreases according to the location of altitude to a height of 10km with a temperature gradient decreased from 5.0 to 6.5°C per 1000m above sea level. Decreasing temperature according to the place where the altitude is possible due to several reasons, among others: a) the effect of the ambient temperature near the earth's surface; b) the effect of the

oceans; c) the effect of air density; d) indirect effect of the wind; f) effect of latent heat; g) ground cover; h) type of soil; i) effect of sun angle [5].

Diffuse sound waves in the air were reduced once it is absorbed by the air and other objects in between the plants. Plants that effective noise reduction is that have leaves all year round with a dense pattern of leaves that spread to the surface of the ground. Noise reduction by plants was different, depending on the size and density of the leaves [6]. Planting multiple species simultaneously is more effective in reducing the noise of the single planting. If the thin buffer was effected as a visual buffer or protective sunlight, then reverse the sound buffer should have a larger size [7]. The size and density of plants is critical in controlling noise. Trees can reduce noise by absorbing sound waves by the leaves, branches and twigs. The most effective type of plant to muffle the sound is having a thick canopy of leaves that shade [8]. Acceptable level of noise is influenced by environmental factors, namely wind direction, temperature, and humidity. The noise level can be reduced by plants is also influenced by the intensity, frequency, and direction of the sound [9].

What is the level of noise can be controlled by vegetation depends on: a) the type species, plant height, density, and distance grows, b) climatic factors, namely wind speed, temperature, and moisture, and c) the voice type, origin and decibel level (level of intensity). Sound waves are absorbed by the leaves, the branches, the twigs of trees and shrubs. It has been reported that the most effective part of the plant for sound absorption is a part that has thick leaves, fleshy with lots of petiole (leaf stalk). This combination provides a high level of flexibility and vibration [8].

Methods

The main highway Waru-Sidoarjo in East Java Province is located more than 49 km in length (Fig. 1).

Fig. 1. Four Point Research Sites on the highway Waru - Sidoarjo, East Java, Indonesia

The noise level of the highway has been shown to exceed the quality standards, which were based on research, that the noise levels due to traffic on the highway Waru-Sidoarjo in 2001 ranged from 63-80dBA [10]. As for noise standards, noise levels which over 75dBA were very risky for humans [11]. Noise generated by the motor vehicle noise, especially from vehicle engines, exhaust, and because the interaction between the wheels with the road, and the main source of noise on the highway is heavy vehicles and passenger cars. The average temperature on the side of the road in the region is between 35 - 41.2°C. The high temperatures in the region caused fuel vehicles passing through the highway, the sun reflection on the asphalt on the road, many settlements along the highway.

The study was conducted at 4 point locations with different compositions: composition A, composition B, composition C and composition D. Composition A is located at km 27 the tree-shrubs-bushes (1-1-1), composition B is located at km 23 was without vegetation (0-0-0), composition C was located at km 33 the tree only (1-0-0) and composition D is located at km 31 the tree-shrubs (1-1-0), as shown in figure 2.

Fig. 2. Research areas for each vegetation composition: a – composition A at Km 27, b – composition B at Km 23, c – composition C at Km 33, d - composition D at Km 31

The survey was conducted by observing the composition of the vegetation. Noise is measured with a Sound Level Meter (SLM), CE, Model: AZ8925, made in Taiwan Taichung. Temperature measurement is done using a thermometer on Cup Anemometer Barometer Humidity Thermometer, Lutron, ABH-4224 models, made in Taiwan. Three pairs of equipment

(the SLM and thermometer) placed at a distance of 5 meters, 8 meters and 10 meters from the center of the road, was measured at the same time simultaneously. All of these measurements were repeated 5 times.

Once grouped, the data are processed using MS Excel and then calculated the difference between the average noise level and the average temperature at a distance of 5, 8 and 10m for each composition of vegetation, along with the standard deviation. Then look for the percentage difference between the noise level and temperature measurements along the highway and at a distance of 8m and 10m, for each vegetation composition. Then for creating charts by using Ms Excel chart. Graphs of the results could be compared effectiveness in reducing noise and lowering the temperature in each vegetation composition.

Result and Discussions

Noise and temperature are a problem predominantly for residential location on the highway. Arrangement of plants with good composition will reduce the problems increase in noise and temperature for communities around the toll road. Influence the composition of the vegetation around the toll road to the noise caused by vehicles listed in Table 1.

Table 1. The average and standard deviation of the noise level for each composition

Distance (m)	The Average and Standard Deviation of Noise Level (dB)			
	Composition A: Tree-shrubs-bushes	**Composition B: Without vegetation**	**Composition C: Tree only**	**Composition D: Tree-shrubs**
5	75,28 ± 2,63	75,62 ± 2,40	82,61 ± 5,99	76,98 ± 4,63
8	72,20 ± 3,16	72,38 ± 3,45	78,02 ± 5,20	74,28 ± 4,56
10	66,06 ± 4,98	68,42 ± 4,88	73,50 ± 5,41	69,50 ± 5,71

In Table 1, Composition A is the best composition for noise reduction, the graph can be seen in figure 3a and 3b. Vegetation as a barrier on the side of the highway has been proposed as a potential air pollution mitigation strategies [12]. To plant the several species by collectively was more effective in reducing the noise of the single planting [9]. A variety of crops with different strata high and tight enough ways to be able to reduce the noise [8]. The space between the leaves allow sound to penetrate into the vegetation and then pass to the back of vegetation. The sound energy hit the vegetation, and then reflected, absorbed, distributed, deflected, or forwarded by the leaves as a sound barrier field on vegetation. Reflection, absorption, deflection, or forwarding voice is influenced by leaf thickness, density, leaf angle to the direction of the sound energy come, and position among the leaves [13]. The change in the transmission path will increase the length of travel for the wave and get absorbed, refracted and radiated into the surrounding environment. The noise pollution can be reduced during transmission path by vegetation [14].

Table 2. The average and standard deviation of temperature for each composition

Distance (m)	The Average and Standard Deviation of Temperature (°C)			
	Composition A: Tree-shrubs-bushes	**Composition B: Without vegetation**	**Composition C: Tree only**	**Composition D: Tree-shrubs**
5	37,92 ± 0,55	37,94 ± 1,61	36,09 ± 1,12	37,09 ± 0,92
8	36,95 ± 0,99	37,46 ± 1,67	35,43 ± 0,99	36,12 ± 0,73
10	34,82 ± 1,17	37,33 ± 1,71	34,61 ± 0,71	35,45 ± 0,67

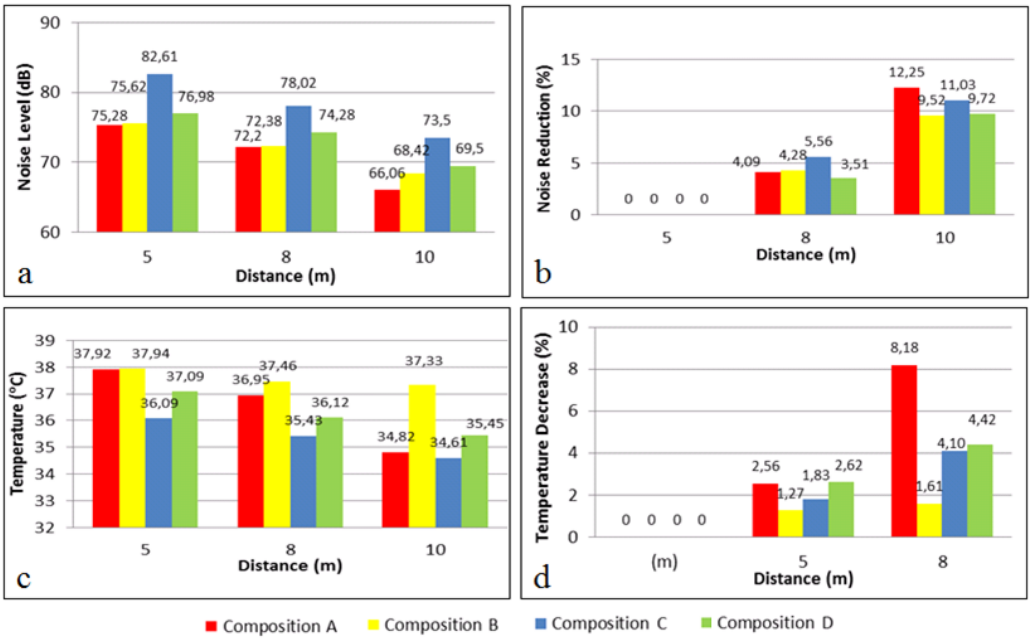

Fig. 3. Graphics of values for each vegetation composition: a - Average of Noise Level, b - Average of Noise Reduction, c - Average of Temperature, d - Average of Temperature Decrease

The influence of plant composition around the highway to temperature was caused by human activity listed in Table 2. Composition A is the best composition for the temperature decrease, the graphs could be seen in figure 3c and 3d. The vegetation imposes a drag on the air moving through the leaves and branches. This flow obstruction causes some air to move up and around the canopy [12]. Temperature rising was followed by increased evapotranspiration of plants, so water needs will be increased. The increase in the rate of evaporation will increase the formation of clouds, rainfall will increase above normal. The existence of hot spots scattered in several places allowing uneven rainfall. Solar radiation absorbed by vegetation used for photosynthesis together with carbon dioxide (CO_2) in the air. The activities of the process of photosynthesis and evapotranspiration will lead to a drop in temperature as well as the production of oxygen (O_2) that can cool the environment [15]. Areas with higher extensive tree density and tree canopy cover allowed air mass which was containing water vapor could not move quickly, cause of high humidity [16].

From figure 3b it can be seen that for the composition A, the composition of the tree-shrubs-bushes, obtained the highest noise reduction up to 12.25%, compared to the other compositions. From figure 3d it can be concluded that planting composition A can lower the temperature up to 8.18%. Composition A, the composition of tree-shrub-scrub was the best composition for reducing air pollution, especially for noise reduction and decrease in temperature.

Placement of plants on the path separator in accordance with established rules, generally only suitable planted shrubs or bushes. At the city park, which can function as a "lung" of the city, a combination of all three types of plants could be used. Benefits of green open space like this, the most important is the safety of the environment in urban areas of various forms of

pollution, including air pollution role in improving the quality of the street environment, shrub is one of the types of plants that can be combined with shrubs or trees. In this case, not in terms of aesthetics alone, but needs to be studied role in improving the service road users and the surrounding environment, which include convenience in terms of health, pollution reduction that occurs at a site [12].

Conclusion

Of various vegetation compositions as the sample of this study, was evident that the most effective vegetation composition as a noise and temperature reducer is the vegetation composition with trees-shrubs-bushes. Planting vegetation with trees-shrubs-bushes composition along the side of the highway will be more effective to reduce noise and temperature pollution which was from human activities.

References

[1] B.Lakitan, **Dasar-dasar Klimatologi**, Raja Grafindo Persada, Jakarta, 2002.

[2] S. Tampubolon, **Pengaruh Kecepatan Angin dan Suhu Udara Terhadap Kadar Gas Pencema Karbon Dioksida (CO_2) di Udara Sekitar Kawasan Industri Medan (KIM),** Universitas Sumatera Utara, Medan, 2010.

[3] S. Djalante, *Analisis Tingkat Kebisingan di Jalan Raya yang Menggunakan Alat Pemberi Isyarat Lalu Lintas (APIL),* **Jurnal Smartek, 8**(4), 2010, pp. 280-300.

[4] C.E. Mediastika, **Akustika bangunan: Prinsip-prinsip dan Penerapannya di Indonesia**, Penerbit Erlangga, Jakarta, 2002.

[5] S., Wisnubroto, S.L., **Aminah, M. dan Nitisapto, Asas-asas Meteorologi Pertanian**, Ghalia Indonesia, Jakarta, 1981.

[6] D. Yuliarti, **Karakteristik Tanaman yang Efektif Mereduksi kebisingan**, Skripsi, IPB. Bogor. 2002.

[7] J. Chiara, L.E.Koppelman, **Standar Perencanaan Tapak**, Penerbit Erlangga, Jakarta, 1997.

[8] G.W.Grey, F.J.Deneke, **Urban Forestry**, John Willey and Sons, New York. 1978

[9] C.P. Carpenter, E.R. Kinkead, D.L. Geary Jr, L.J. Sullivan, J.M. King. Petroleum hydrocarbon toxicity studies. V. Animal and human response to vapors of mixed xylenes. **Toxicology and Applied Pharmacology**, **31**, 1975, pp. 543-558.

[10] R. Setiawan, T.D. Arief, N. Handayani, P. Sawitri, *Studi Awal : Analisa Tingkat Kebisingan Lalu Lintas Pada Jalan Tol Ruas Waru – Sidoarjo*, **Jurnal Teknik Sipil,** Fakultas Teknik Sipil dan Perencanaan Universitas Kristen Petra, Surabaya, 2001.

[11] * * *, **Pedoman Mitigasi Dampak Kebisingan Akibat Lalu Lintas Jalan**, Badan Litbang PU Departemen Pekerjaan Umum, Jakarta, 2006.

[12] J.T. Steven, Y.J. Wang, K.M. Zhang, *Exporation of Effect of a vegetation Barrier on Particle Size Distributions in a Near-Road Environment*, **Atmospheric Environment,** Elsevier, **50,** 2012, pp. 120-128.

[13] S. Widagdo, *Studi tentang Reduksi Kebisingan Menggunakan Vegetasi dan Kualitas Visual Laskap Jalan Tol Jagorawi*, **Program Pasca Sarjana**, Institut Pertanian Bogor, Bogor, 1998.

[14] A.V. Tiwari, P.A. Kadu, A.R. Mishra, *Study of Noise Pollution Due To Railway and Vehicular Traffic at Level Crossing and Its Remedial Measures*, **American Journal of Engineering Research (AJER), 2**(4), 2013, pp. 16-19.

[15] E.N.K. Dahlan, H.M.Y. Fakuara, *Hutan Perkotaan Menjawab Isu Pemanasan Global*, **Prosiding Seminar Nasional Perubahan Iklim Bumi, Perhimpunan Meteorologi Pertanian Indonesia-Balitbang Kehutanan-Masyarakat Kehutanan Indonesia**, Jakarta, 1990.

[16] H.S. Hendy, *Pengaruh Ruang Terbuka Hijau kota (RTHK) Terhadap Iklim Makro dan Indeks Ketidaknyamanan*, **PhD.Tesis**, Universitas Gajah Mada, Yogyakarta, 2001.

[17] N. Kusminingrum, *Peranan Tanaman Semak dalam Upaya Mengurangi Polutan NO_x dan CO_2*. **Jurnal Jalan-Jembatan, 24**(3), 2007, pp. 287-298.

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