The role of application of vertical greenery systems on the Jakarta-Cikampek elevated toll road

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Abstract. The Indonesian government has been focusing on the development of the transportation sector for the past several years. It is done to increase the movement of people and goods, which will improve the economy. One of the transportation projects that has been undertaken is the construction of the Jakarta-Cikampek Elevated Toll Road. The construction of this project has given a change in travel time. However, on the other hand, new problems have arisen, including increases in air pollution, air temperature, and impaired vision. One way to deal with this problem is by greening. The purpose of this study is to provide a concept of handling with an optimal green line to minimize the impact that appears. The method used is a literature review which includes: the selection of planting methods, analysis of CO pollutants, analysis of noise pollution, and analysis of temperature. The result of analysis shows that the most appropriate concept of the vertical greenery system is by using vines. This concept was chosen because it will optimize vacant land in the green belt bellow the overpass as planting medium. The application of the vertical greening system will reduce the CO concentration value by 33.33%, so that the average concentration will become 199.659 ppm. The application of this system can reduce noise pollution by 3 dBA, so that the noise intensity will be reduced to 50-79 dBA with an average of 74.5 dBA. This system will provide a temperature reduction of 1.2°C so that there will be a decrease in the average temperature to 28.2°C.
Key Words: elevated toll road, noise, pollution, temperature, vertical greenery system.

Introduction. Transportation has always been a part of life activities, both for moving people and godos (Blume et al 2022). Without transportation, people or goods will not be able to travel. The Indonesian government for several years has focused on developing the transportation sector (Kadarisman et al 2015). This is done to increase the movement of people and goods, which will improve the economy. One of the transportation projects that have been undertaken is the construction of the Jakarta-Cikampek elevated toll road. This toll road is built along 36.84 kilometres and located in the middle of the Jakarta-Cikampek Toll Road (Khalim et al 2020). This toll road crosses Bekasi City, Bekasi Regency, and Karawang Regency. The purpose of the construction of this toll road is to separate the Jakarta-Bekasi-Cikarang commuter route (collector/ existing line) from long-distance travel routes to Cirebon, Bandung, Semarang and Surabaya (express/elevated lanes).

The construction of the Jakarta-Cikampek Flyover Toll Road project has made changes especially in travel time. But on the other hand, new problems arise. Changes in land use that were use initially as green open space are reduced due to the development. The increase in vehicle traffic around the construction site will also increase air pollution. The construction of the toll road will increase the traffic of passing vehicles which will also have an impact on rising temperatures around the construction. Another impact is noise pollution. Noise pollution increases with increasing traffic. This is also reinforced by the design of the toll road at the top, which causes the sound to spread further.

The Environmental Quality Index Report 2015-2018 (2019) provides information that the historical value of the Environmental Quality Index (EQI) data of DKI Jakarta Province in 2015-2018 has a value of 43.79 (very poor), 36.69 (alert), 35.78 (alert), and

45.21 (very poor). Meanwhile, West Java Province has historical data on the 2015-2018 EQI values as follows 63.49 (good enough), 51.87 (not good), 50.26 (not good), and 56.98 (not good). It is known that the index value of the two provinces can be said to have a low value. The 2018 Environmental Quality Index Report (2018) states that the EQI value of West Java Province is mostly influenced by the Air Quality Index of 72.80 and the Water Quality Index of 65.77, while the Land Cover Quality Index is only 38.51. Meanwhile, in DKI Jakarta Province the largest EQI was also influenced by the Air Quality Index of 66.57 and the Water Quality Index of 51.93, while the Land Cover Quality Index was only 24.14. The 2018 EQI data illustrates that the quality of the environment in West Java Province is not good and DKI Jakarta is already in a very poor stage. One of the causes of this problem is development in the transportation sector, especially toll roads.

Handling problems related to air pollution, noise pollution and temperature increases can be done in many ways, one of which is greening. Greening has many methods, one of which is a vertical greenery system (Coma et al 2019). This research will provide an optimal green line treatment concept in order to minimize of air pollution, noise level, and temperature.

Material and Method

Data collection. Data for this research is secondary data. Data was obtained from various sources such as Indonesian government regulations, book report, journals, as well as theory development and case studies. The data used in this research were temperature data, noise value data, and traffic volume data. Data of traffic volume collected from PT. Jasa Marga (2020) is data on vehicles going in and out of Jakarta via the Jakarta-Cikampek Toll at the Cikampek Utama Toll Gate. Noise data is obtained from environmental impact reports (PT. Sarana Perencana Jaya 2017).

Figure 1 shows the traffic volume of Jakarta vehicles through the Jakarta-Cikampek toll road at the Cikampek Utama toll gate. The data was taken in the span of one month in February 2020. The lowest data occurred in the volume of 13416 vehicles, while the highest volume was 20974 vehicles with an average vehicle volume of 16172 vehicles.

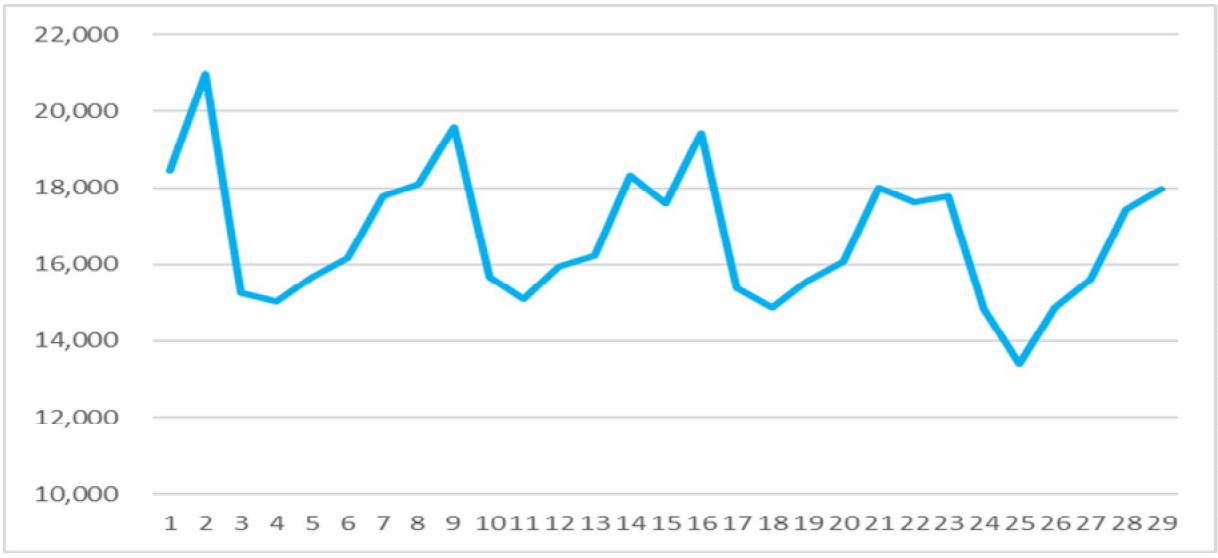

Figure 1. Traffic volume Jakarta-Cikampek toll road in February 2020.

Figure 2 shows the historical data on temperature around the Jakarta-Cikampek toll road area. The data was taken in the span of one month in February 2020. The lowest temperature occurs at 28°C, the highest temperature is at 34°C and the average temperature is 30°C.

Sound noise data is obtained from the Addendum Andal and RKL-RPL report for the construction of the Jakarta-Cikampek II Elevated toll road (PT. Sarana Perencana

Jaya 2017). Noise data is obtained with a value between 53 and 82 dBA with an average value of 77.5 dBA.

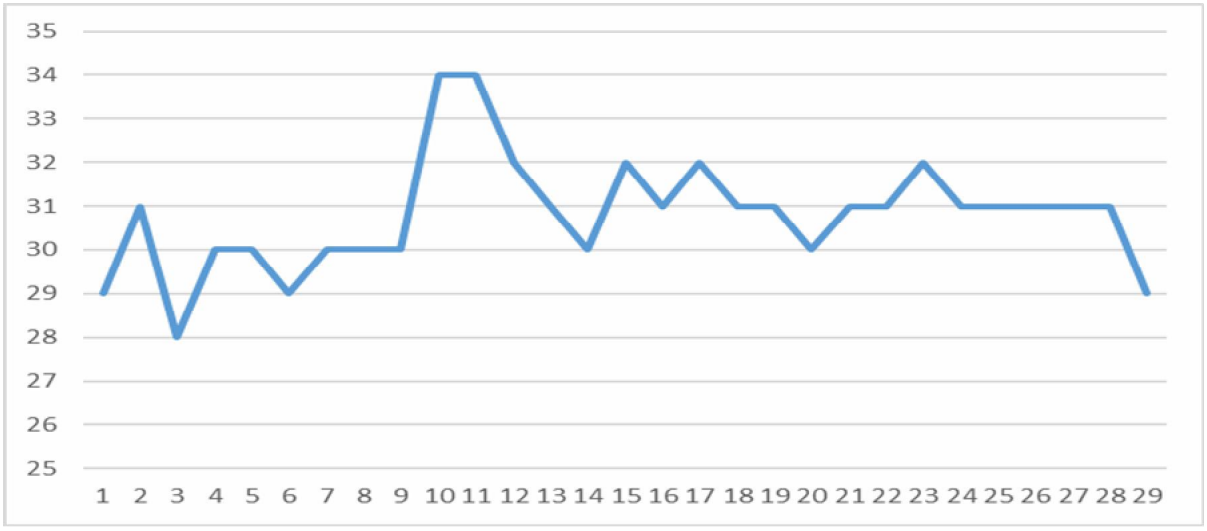

Figure 2. Temperature history data in February 2020.

Method of analysis. The method of analysis used literature study. Air pollution analysis was performed by calculating the value of pollutants based on the Hobbs Pollutant Regression Model calculation method (Hobbs 1979). This model uses traffic volume data as the basis for its calculations. The pollutant values calculated is the concentration of Carbon Monoxide (CO). Noise level and temperature were calculated using parameter values taken from other studies.

Result and Discussion

Vertical greenery system topology. The Vertical Greenery Systems has various topology systems. Wong et al (2010a, b) divided them into two patterns, namely the living wall and green façade. The living wall is a planting model on the wall that uses planting media, while the green façade is a planting system that uses vines that are planted in the ground and that also cover the walls. Safikhani et al (2014) divided them into four, namely tree-against-wall type; wall-climbing type; hanging-down type; and module type. Tree-against-wall type is a planting system that uses tree-type plants that are planted opposite the wall. Wall-climbing type is a planting method using vines. It is planted in the ground so that the vines are on the wall. Hanging-down type is a method of planting on a wall using hanging plants. Module type is a planting method using planting media and small plants.

Various methods of vertical greenery system have advantages and disadvantages. Seeing the field conditions on the Jakarta-Cikampek Elevated Toll Road, the appropriate method to use is either the green façade or wall-climbing type method. This method was chosen considering that under the toll road there is still free space that can be used as planting media.

Figure 3 is the application of vertical greenery system design. It is carried out by planting in an empty land area under the Jakarta-Cikampek Elevated Toll Road and directed upwards (elevated road) using wire media. The planting design on the elevated road is formed using wire mesh media that forms the edge wall along the elevated road.

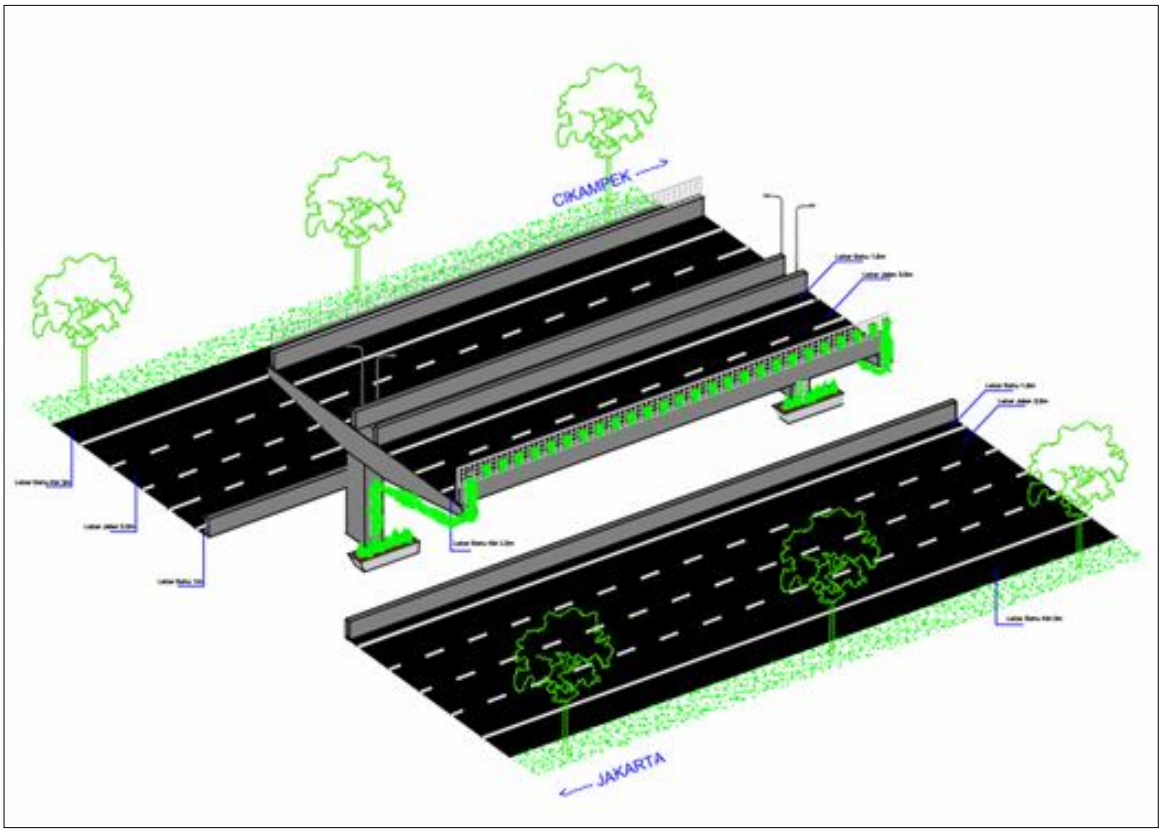

Figure 3. Application of vertical greenery system design.

Types of plants. There are many types of plants to use in the vertical greenery system (Pan et al 2020). However, with the type of design chosen, the selection of plant types is only on the type of vines. There are several vines that can be used, including sirih gading (devil's ivy), bitter melon (*Momordica charantia*), morning glory (*Ipomoea tricolor*), apios (*Apios americana medicus*), and sword bean (*Canavalia gladiata*). However, from all of them the most suitable for use in the research location is sirih gading (devil's ivy) (Putrianingsih & Dewi 2019).

Air pollution. Air pollution analysis was carried out by calculating the carbon monoxide concentration value using the Hobbs regression model (Hobbs 1979). Carbon monoxide concentration (CO) is calculated in parts per million (ppm) which is calculated by the volume of the vehicle during the an hour period in road shoulder of elevated road.

Figure 4 is the analysis result of calculating the value of pollutants in a 1 hour volume period. The analysis showed that CO concentrations in the region ranged from 192.049 ppm to 464.817 ppm with an average of 299.473 ppm.

Adita & Ratni (2013) in their research showed that the efficiency level of absorption of carbon monoxide gas on plants at the exposure time of an hour on the fifth day in lidah mertua (*Sansevieria* sp.) was 40.88%, lili paris (*Chlorophytum comosum*) 36.48%, and sirih gading (devil's ivy) 33.33%. In that case, the application of the vertical greenery system using devil's ivy plant will be able to reduce the carbon dioxide level by 33.33%. So that the lowest concentration will decrease to 128.039 ppm, the highest concentration will sink to 309.894 ppm and the average concentration will become 199.659 ppm.

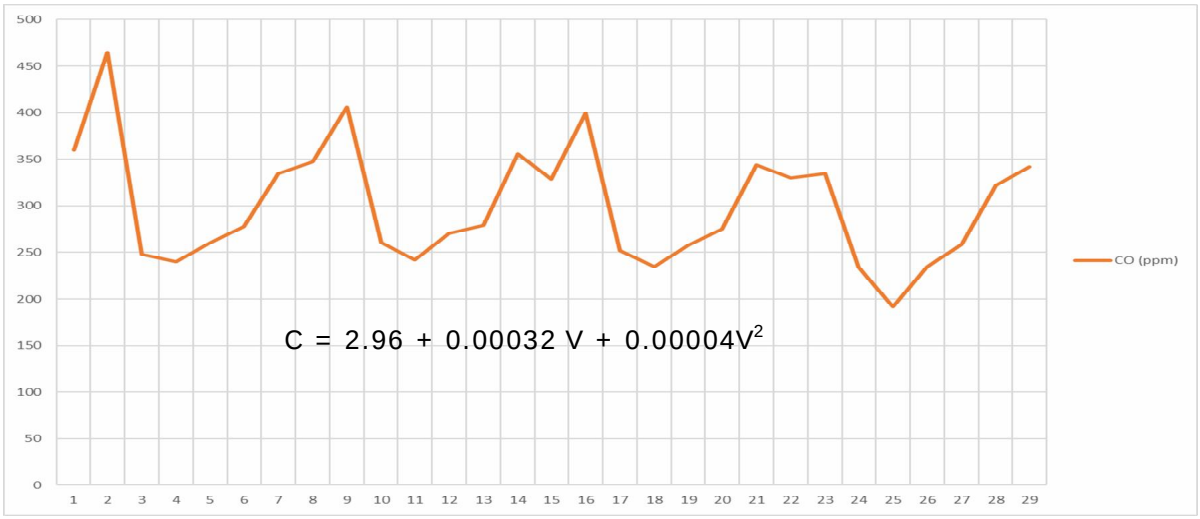

Figure 4. Air pollution based on traffic volume 1 hour period.

Noise level. The application of vertical greenery is carried out by planting in an empty land area under the Elevated Road and directed upwards (elevated road) using wire media. The planting design on the elevated road is formed using wire mesh media that forms the edge wall along the elevated road (see Figure 3).

Green facades mute street noise from 2.5 dB to 3dB and ensure that internal reverberation between facades on each side of the street is reduced (Wong et al 2010a, b). Noise intensity originating from vehicle engine activity reached 53-82 dBA with an average of 77.5 dBA. The application of this system can reduce noise pollution by 3 dBA, so that the noise intensity will be reduced to 50-79 dBA with an average of 74.5 dBA.

Temperature. This system will provide a temperature reduction of 1.2°C so that there will be a decrease in temperature to 26.8°C for the lowest temperature, 32.8°C for the highest temperature and an average temperature to 28.2°C.

Conclusions. The result of the research shows that the most appropriate concept of vertical greening system is by using vines. This concept was chosen because it will optimize vacant land in the green belt bellow the overpass as planting medium. The analysis showed that CO concentrations in the region ranged from 192.049 ppm to 464.817 ppm with an average of 299.473 ppm. The application of vertical greening system will reduce the CO concentration value by 33.33%, so that the lowest concentration will decrease to 128.039 ppm, the highest concentration will sink to 309.894 ppm and the average concentration will become 199.659 ppm. Noise intensity originating from vehicle engine activity reached 53-82 dBA with an average of 77.5 dBA. The application of this system can reduce noise pollution by 3 dBA, so that the noise intensity will be reduced to 50-79 dBA with an average of 74.5 dBA. Existing temperature value is the lowest at 28°C, the highest at 34°C with an average of 30°C. This system will provide a temperature reduction of 1.2°C so that there will be a decrease in temperature to 26.8°C for the lowest temperature, 32.8°C for the highest temperature and an average temperature to 28.2°C.

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