

Implementation of Soundscape at Rail Boundaries Case Study: Jl. Haur Jaya, Bogor City

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Abstract: Bogor is an area that accommodates the needs of the capital city of Jakarta (Wilza et al., 2021), this high population rate has contributed to dense settlements to facilitate their lives and activities, for people who have financial limitations choose an alternative to building their homes on the railroad tracks (Prihatiningsih & Rahmawati, 2018). The railway line is supposed to function as a 10-meter-wide vacant land where 6 meters of this border is supposed to be used to reduce noise pollution by using a noise barrier to achieve a standardized noise level in settlements of 55Db(A) (Department of Public Works, 2005). The outdoor acoustic environment is a diversity that is managed and enhanced, to control noise from the environment (Brown, 2010). With the Descriptive Analysis method on Jalan Haur Jaya, Bogor City. Noise data was taken with the SANFIX type WT85B Sound Level Meter instrument with a measurement time of 24 hours carried out 4 times at 4 measurement points. Soundscape is a solution to improve the quality of living comfort by applying the right arrangement of plants to reduce noise pollution, shade, absorb air pollution, windbreaker and view barrier (Syahindra et al., 2014) in this settlement obtained Leq 100.2 dBA, with the applied plant composition able to reduce noise by 48.25 dBA, this settlement meets the standard of residential noise.

Keywords: soundscape, railroad, residential

1. Introduction

In 2020 the population census was carried out, and the data obtained from the census for that year was 270,203,900 people. From this data, it is projected that in 2022 the population of Indonesia will be 275,773,800 people (Central Bureau of Statistics, 2022b). Java Island is the most populous island with a percentage of 51.47% of the population living on the island of Java, West Java occupies the first level with a percentage of 35.73%, followed by East Java with 28.80%, and other provinces (Central Bureau of Statistics, 2022a) and Bogor Regency is the area with the most population compared to other regions followed by Bandung Regency and then Bekasi Regency (West Java Central Bureau of Statistics, 2020). The city of Bogor and Bogor Regency are areas that accommodate the needs of the capital city, Jakarta, which has great potential for development and growth of the economy and services for Indonesia, a national activity center for industry, trade, transportation, communication, and also tourism. (Wilza et al., 2021) with this high population rate resulting in the density of settlements to facilitate their life and activities, people who have financial limitations choose alternatives to build their homes on the border of the railroad (Prihatiningsih & Rahmawati, 2018) which is an area with a high noise level and the City of Bogor has a station with a very high level of train departures and arrivals in West Java, almost every 10 minutes there are departures and arrivals of trains to this

station(Azhima, 2020; PT KAI, 2022)those who live in Bogor feel that working in the capital city and returning home within no more than 24 hours is very effective, besides the price of housing in Jakarta and the high cost of living they choose to live in Bogor, this is not solely because in DKI Jakarta they can get a bigger salary than the city they are in but because the facilities from PT KAI are the most effective in terms of time and economy(Irjayanti et al., 2021).

Settlements that are close to noise centers are a serious matter to pay attention to because many negative effects affect people living in settlements with high noise levels. Excessive noise causes discomfort or potential for physical harm. This is called noise pollution. Especially air pollution caused by machines and transportation systems affects the activities or balance of human and animal life. Most of the sources of outdoor noise worldwide are mainly caused by the machinery and systems of transportation, cars, airplanes, and trains which are summarized in terms of environmental noise. (Organization, 1980; Templeton, 2017). The railroad border should function as a 10-meter wide vacant land where 6 meters of this open space is intended for utilities from the railroad activities, outdoor recreational facilities that do not cross roads, transportation infrastructure, and tree planting activities. (Bogor Regional Regulation No. 23, 2016; Bogor Regency Regional Regulation No. 4, 2016)This barrier should be used to reduce noise pollution caused by noise from the railroad track, one of which is by using a noise barrier to achieve standardized noise levels in housing and settlements of 55Db(A)(Department of Public Works, 2005).

A natural noise barrier approach with the application of a soundscape, Soundscapes which means landscape (scape) is defined as placing objects in an environment that is not limited in scope, combined with sound or tone (sound). In a narrow frame, the field of view can be a room; while with wide coverage, visibility is not limited to that area(Nakagawa, 2000), The outdoor acoustic environment is a resource whose diversity must be managed and improved, to control noise from the environment(Brown, 2010), Positive response from visitors to the Yogyakarta Grand Mosque regarding the soundscape approach of vegetation, water, and open space in the courtyard of the mosque. The sound that exists due to activity chatter and the physical environment of the area causes noise to come out, by placing a sustainable value on the space in the courtyard of the mosque and building a mediative atmosphere, this soundscape experience can foster tolerance, familiarity, calm, freshness & serenity during activities, can be a supporting element in the sustainability space(Syamsiyah et al., 2019). This soundscape approach will be applied to the railway border in the settlement of Jl Haur Jaya, Bogor City to meet noise standards in residential areas.

2. Research Methods

The study was carried out using the Descriptive Analysis method, first formulating the problems that occur from the location that will be discussed, then preparing for data collection at the location that will be studied(Fabiana, 2019), in this study, namely Jalan Haur Jaya, Bogor City. Noise data was taken using the SANFIX type WT85B Sound Level Meter instrument with a measurement time of 24 hours carried out 4 times at 4 measurement points, morning 05.00-08.00, noon 11.00-13.00, afternoon 04.00-18.00, and night 21.00-23.00. Voice is recorded at intervals of 5 seconds once for 10 minutes which will produce 120 data. From these data, we can know the average value of noise in the environment. These results will be analyzed to find solutions with an architectural approach to sustainable soundscape architecture to reduce noise pollution in the Jalan Krisik settlement, Bogor City.

3. Results and Discussion

3.1 Noise

The noise itself is a sound source that causes living things in the environment to feel disturbed by sounds that interfere with their activities.(Sugiarto & Wijaya, 2019), what is

continuously affected is the health of these humans who are exposed for a long time because the sound received by the auditory nerve does not want this stimulation (Syamsiyah et al., 2019)

a. Types of Noise

This noise is categorized into several types or categories based on the noise source to explore where the noise source is and also to map out solutions to dampen the noise. This noise is categorized into 3 categories, namely;

1. Impulsive Noise, this noise does not occur continuously but occurs little by little. For example the sound of a hammer being hit, the sound of a rigging machine.
2. Continuous Noise is the noise that occurs continuously. Example of Noise when the engine starts or starts.
3. Semi-continuous noise, which is continuous noise that only lasts for a moment, then disappears and can reappear. Example: the sound of a car, train, or plane passing by.

Loud noises, loud sounds are indeed very disturbing, especially if they occur sporadically and suddenly the effect will be very disturbing if the source of the noise is unknown (Wisnu, 2009).

b. Noise Impact

The results of research in the City of Madiun, in people who live next to the railroad tracks with settlements intersecting with the railroad tracks as far as 3-8 meters and the noise level at 66-67 dB, from the results of measuring the increase in pulse rate from a sample of 30 people who participated 53.33% (16) people who participated in the sample experienced a change in pulse rate, and 46.67% (14) people did not experience a change in pulse rate, even though they lived in the same settlement. Then the results of hearing health checks showed that out of 30 people, 17 people had hearing loss as much as 56.67%, and as many as 13 people, namely 43.33%, were in good health. (Sunaryo, 2021).

c. Noise Barrier

Efforts to reduce air pollution are usually carried out by installing sound absorbers (BPB). Noise Barriers can be natural barriers and artificial barriers. Natural barriers usually use several combinations of plants and embankments, while artificial barriers can be made of various materials such as massive walls made of several combinations of materials or just one material that is a sound barrier. The working principle of BPB reflects, dampens, and changes the path of noise sources. (See Figure 1).

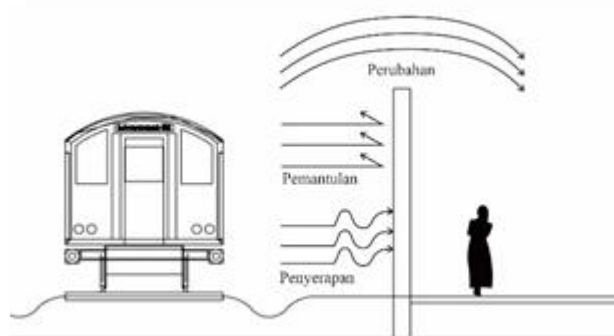


Figure 1. BPB Basic Principles

Source : (Department of Public Works, 2005)

Leaf density and plant density used as noise barriers must be sufficiently high and must be uniform at the expected height from the ground surface. Therefore, it is necessary to arrange a combination of ground cover, shrubs, and trees or a combination with other materials, so that the retaining effect is optimal (See Figure 2). Plants that can be used include Grasses that function as ground cover, Shrubs that are effective at reducing noise including Pringgodani Bamboo, Likuan-Yu, Bad Boys, Soka, Rubber, and Teh-tehan, for tree species with dense leaf density with lower branches such as Acacia, and

Johar(Department of Public Works, 2005). In addition, the height of the noise-receiving building must be balanced with the height of the trees, landfills are very effective at absorbing noise sources which are also very effective at absorbing noise. (Ayumna, 2022).

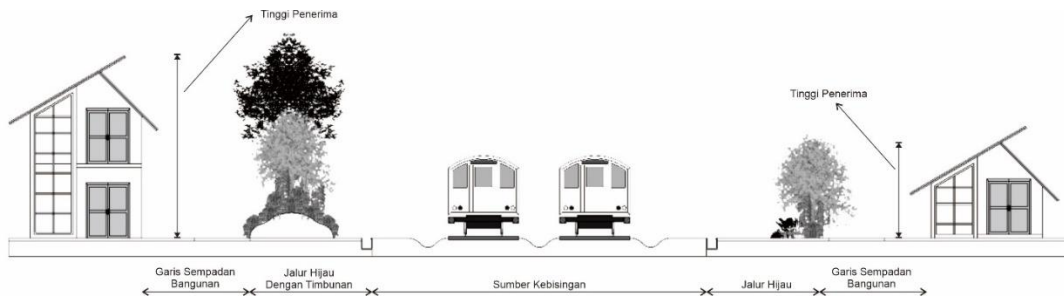


Figure 2. Unfilled and Unfilled Plant Barriers
Source :(Department of Public Works, 2005)

3.2 Overview of Research Locations

The city of Bogor, which is known as the city of rain, is due to the high intensity of rain on the island of Java. Besides that, Bogor also has a high commuter rate and trains are the transportation that commuters enjoy the most, which makes this city always passed by trains for at least 10 minutes a day. time(Leliana et al., 2020; Mulyana, 2012), where the noise level in residential areas close to the paths traversed by the trains becomes less comfortable for living, then the phenomenon that occurs is the border of the railroad tracks which should be a green open space(Bogor Regency Regional Regulation No. 4 of 2016, 2016)As in Jalan Haur Jaya, Bogor City, you can see at a glance on the map (See Figure 3), illegal settlements along this railroad were built above the railroad tracks (See Figure 4.5). This is very detrimental to PT. KAI, as well as residents who are exposed to noise pollution every day, such as along Jalan Haur Jaya, are inversely proportional to the road across from Jalan Bubulak, where there are no permanent buildings along the railroad tracks (See Figure 6.7).



Figure 3. Map of Jalan Haur Jaya and Jalan Bubulak
Source :(Google Earth, 2023)



Figure 4. Photo of Settlement Jl Haur Jaya
Source: Doc. Personal



Figure 5. Settlement Photo of Jl. Haur Jaya
Source: Doc. Personal



Figure 6. Photo of Settlement of Jl Bubulak
Source: Doc. Personal



Figure 7. Photo of Settlement of Jl. Bubulak
Source: Doc. Personal

On Jalan Bulbulak, residents take advantage of this rail border for temporary car parking, and semi-permanent stalls, and local people also use this open area as an object to unwind in the afternoon to see the trains crossing this area in the afternoon just to eat snacks or chatting (See Figure 8,9,10).



Figure 8 Utilization of Railway Borders on Jl. Bubulak, Bogor City
Source: Doc. Personal



Figure 9 Utilization of Railway Borders on Jl. Bubulak, Bogor City
Source: Doc. Personal



Figure 10 Utilization of Railway Borders on Jl. Bubulak, Bogor City
Source: Doc. Personal

3.2.1 Noise Level of Research Locations

With the SANFIX type WT85B Sound Level Meter instrument with a measurement time of 24 hours carried out 4 times at 4 measurement points (see figure 11), morning 05.00-08.00, noon 11.00-13.00, evening 16.00-18.00, and evening 21.00-23.00 obtained results of the lowest, highest, and average noise levels using the formula Then the data is processed to obtain equivalent noise level data using the following formula: $Leq = 10 \log_{10} \frac{1}{n} \sum T_n \cdot 100.1 \text{ Ln dB(A)}$, Then the results Leq is compared with the quality standard according to KepMenLH No.Kep-48/KEP/XI/1996 concerning Noise Level Standards in settlements.



Figure 11. Mapping Noise Measurement Points
Source : (Google Earth, 2023)

From the field survey results, the Leq calculation results show that the average noise level per day in this environment is 95.1 Dba (Table.1). It is necessary to reduce air pollution in this environment by 40.1 dBA to fulfill the standardized noise level of 55.0 dBA. It can be seen that the noise level at points A and B is lower than points C and D, at Jalan Haur Jaya (Point B) there is a reduction in noise due to 3 factors, namely the difference in ground leveling at point C, the height of the ground from the railroad track area, namely as high as 80cm, while at point A the height of the railway area is as high as 3 meters (See Figure 12) then with the massive building before point B reducing the noise level at point B which benefits legal settlements on Jl. crisis,

Table 1. Noise Measurement Results and Noise Level Calculation (Leq) Jl. Haur Jaya and Jl. Bubulak, Bogor City

Waktu Pengukuran	Jl. Haur Jaya (satuan dBA)						Jl. Bubulak (satuan dBA)					
	Titik A			Titik B			Titik C			Titik D		
	Max	Min	Leq	Max	Min	Leq	Max	Min	Leq	Max	Min	Leq
05.00-08.00	94,0	47,2	97,2	73,1	40,6	81,7	96,0	45,6	100,2	86,8	45,6	84,6
11.00-13.00	96,1	45,6	100,2	72,1	43,2	80,8	101,7	40,0	103,1	81,6	44,4	103,3
16.00-18.00	94,9	49,7	100,8	80,0	44,0	88,7	99,1	45,8	97,0	84,7	44,6	102,0
21.00-23.00	96,5	48,4	97,6	75,6	44,8	89,6	94,0	41,4	100,4	84,7	43,8	93,9
Rata-Rata	95,4	47,7	99,0	75,2	43,2	85,2	97,7	43,2	100,2	84,5	44,6	96,0
Max Kebisingan							101,7					
Min Kebisingan							40,0					
Rata - Rata Kebisingan Lingkungan							95,1					

Source: Doc. Personal



Figure 12. Photo of Differences in Land Leveling

Source: Doc. Personal.



**Figure 13. Distance to Settlements
Jl Haur Jaya**

Source: Doc. Personal



**Figure 14. Distance to Settlements
Jl. Bubulak**

Source: Doc. Personal

3.4 Soundscapes

The development of sustainable architecture is now an issue that is of great concern. This is an attempt to reduce noise pollution in an environment to create a comfortable atmosphere for living. (Yang et al., 2020) and also improve the quality of life of its people with healthy psychological health because it creates a living environment that is calm, comfortable, and has a very effective quality of activities (Wisnu, 2009). Soundscape is a solution to improve the quality of living comfort by applying the right arrangement of plants to reduce noise pollution, shade, absorb air pollution, windbreaker, and view

barrier.(Syahindra et al., 2014)in residential Jalan Haur Jaya, Bogor City. Designing with this soundscape approach if implemented along the railroad tracks will increase the volume of green open space in each city, thereby making every city in Indonesia participate in reducing global warming.(Rosianty et al., 2020).

3.4.1 Sustainable Architectural Design Through Soundscape

Each city has a different city profile, the sound that arises as a result of the activities of the residents that make up the profile of the city(Syamsiyah et al., 2019)especially the city of Bogor, for a few days trying to pay attention when the traffic is not too high around the railroad tracks at the research object, you can hear the sounds of birds and see a lot of sparrows flying around, then the sound of the wind with relatively cool air temperatures, it is undeniable that the city of Bogor is known as the city of rain, smelling of wet soil which makes it comfortable to live in the city of Bogor. Soundscape research is the topic of acoustic ecology. This ecological element plays a role in maintaining architectural sustainability, including regional sustainability. Sustainable architecture is part of an international commitment to sustainability that emphasizes environmental aspects, including economic and social development. Sustainability principles derived from local architecture include climate sensitivity,(Syamsiyah et al., 2019).

The soundscape is the acoustic environment that people experience in context. The term was originally coined by Michael Southworth and popularized by R. Murray Schafer. The history of using soundscapes varies by discipline, from urban planning to natural ecology to computer science(Schaffer, 1997). So the architectural soundscape referred to here is the result of urban planning and design through natural ecology and is also supported by computer science. Schafer also uses soundscapes to reduce or even eliminate noise or noise pollution, because there is also noise that is not loud but disturbing and harmful to the environment (Nakagawa, 2000). It is from this that the Soundscape approach forms the basis for efforts to reduce noise pollution in this environment.

3.4.2 Ability of Vegetation to Reduce Noise

Vegetation can affect noise levels, the denser the title is, the lower the noise level will be. Vegetation can absorb and muffle sound up to 95° by directing sound waves through leaves, twigs, and branches. One of the characteristics of woody plants is that the tree can absorb and reflect sound, converting sound energy into friction or heat energy(Ayumna, 2022). The ability of vegetation to muffle noise is also influenced by the type of canopy, height, shape, and thickness. The lower layer barrier can reduce noise up to 1.25 dBA, the medium layer barrier can reduce noise up to 2.46 dBA, and in the highest category, the high canopy can reduce noise up to 5.79 dBA. The quality barrier can be the most effective in reducing noise because it can exceed the permissible noise level guidelines of 57.73 dBA(Alsaad et al., 2022). The following are the types of plants that are planted in 1m³ and can reduce noise levels(Department of Public Works, 2005):

1. Acacia (*Acacia mangium*) with a height of 4 meters effectively reduces 4.4 dBA.
2. Pringgodani bamboo (*Bambuga Sp*) with a height of 1.2 meters effectively reduces 14.7 dBA.
3. Likuan-Yu effectively reduced 2.3 dBA.
4. Bad Boys can only take 0.8 dBA down.
5. Soka lowered 0.9 dBA.
6. Tea-Tehan can reduce 2.7 dBA.
7. Heliconia sp can also reduce up to 5.0 dBA.

Then when combined with a pile of soil this is also one of the effectiveness in reducing noise, this pile itself can reduce noise up to 3.0 dBA. If combined with plants and shrubs, the pile can increase reducing noise up to 8 dBA, besides this, it makes a plant barrier this is to reduce noise pollution but this is also a green open space that makes the eyes comfortable, improves air quality better, and can also be used by the community to do urban

farming or become residential facilities and infrastructure as a gathering place to enjoy green open spaces in their residential areas(Liu et al., 2014).

3.5 Simulation of the Application of Soundscape on Railway Borders

The application of several plant patterns to determine the effectiveness in reducing noise at this location object can be concluded that at point A a noise reduction of 44 dBA is required, at point B a reduction of 30.2 dBA is required, point C is 55.2, and point D is 41 dBA, that will be studied are point B and point D which are residential areas, with the existing point B this border has been built by illegal settlements which should be replaced by green open spaces, then at point B efforts to reduce noise to 45.2 dBA assuming these illegal buildings reduced to 15 dBA. This effort is very high as the intended drop yields 55.0 dBA according to government regulations, with a limited land area of 6 meters, it must be effective in selecting and designing landscapes to achieve noise reduction. The simulation made for noise reduction is translated into the landscape simulation below according to the existing conditions;

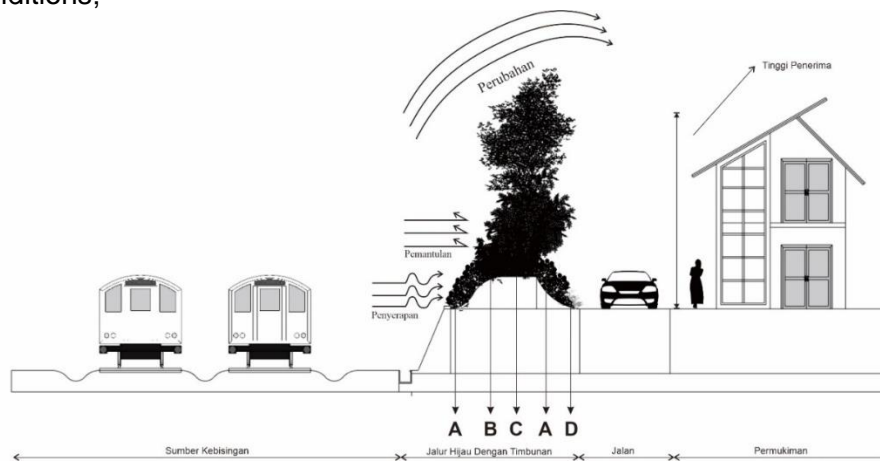


Figure 15 Plant Barrier Simulation

Source: Author

8 dBA, then with this composition it can reduce by 48.25 dBA. For the 3D simulation, it can be seen that the view is from the direction of the railroad tracks (Figure 16), and is seen from the direction of the settlement (Figure 17).



Figure 16. GSKA 3D Simulation

Source: Doc. Personal



Figure 17. GSKA 3D Simulation

Source: Doc. Personal

4. Conclusion

The noise caused by passing trains that pass 2 times every 10 minutes starting from 4 in the morning until 1 at night is very disturbing to settlements that intersect with the railroad tracks, with the presence of these illegal buildings reduces the source of noise

received by 15, 0 dBA, but this is less because at point B it still receives noise at Leq 100.2 dBA, with standardized residential noise of 55.0 dBA, it is necessary to reduce noise to 45.2 dBA assuming illegal buildings reduce to 15 dBA, with a composition of Heliconia plants 1 meter wide, Bamboo 1.5 x or 1.5 meters wide, Acacia 1 meter, Heliconia 1 meter, flower plants, and these plants are composed of piled up the soil as high as 1.5 meters with ground retaining grass can reduce noise by 48.25 dBA, then the Leq of noise or average noise is 51.95 dBA, and is sufficient to meet the standardization of residential noise.

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