The Impact of Sound Sources on Perception Dimensions in Indonesian Settlements Area

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Abstract. The disruptive technology and Covid-19 pandemic situation caused many activities to be carried out at home. Activities at home often cause physical and mental health problems if not supported by an excellent residential environment. The United Nations also emphasized that this attention to physical and mental health is one of the sustainable issues that need to be taken seriously by paying attention to the quality of the surrounding environment. An alternative approach to improve mental health is through a soundscape approach. A soundscape is an approach that investigates the relationship between the acoustic environment and the perception of the environment it evokes. This study tried to look at the relationship between the sound source around the Indonesian settlement area and the residents' resulting perception. Resident's perception data are collected in several residential areas in Indonesia. The results of this study indicate the elements of sound sources that affect the perception of residential areas. These elements need to be regulated to improve physical and mental health in the residential area, to create a more sustainable environment for humans.

Keywords: Soundscape, mental health, acoustic environment, sound sources, perception dimensions, Indonesian Settlements Area.

1. Introduction

The condition of the SARS-CoV2 pandemic throughout the world, especially in Indonesia, has transformed human activity in urban areas. Many activities such as studying, working, and others have to be done online from home to snap the chain of virus spread. Therefore, the relation between residents in urban areas and the surrounding residential environment becomes more intense than usual. Nevertheless, the environmental conditions around the housing often do not support the physical and mental health of the inhabitants. These not supportive conditions can be seen from the perception of noise in the surrounding residential environment.

The noise itself has long affected a person's physical and mental health. Noise that is too loud can cause physical disturbances such as hearing loss, sleep disorders, high blood pressure, and other physical disorders [1, 2, 3]. In addition, many recent studies have stated that noise also causes a person's mental health, especially related to the type of sound apprehended [4, 5]. Therefore, the issue that needs to be considered in planning this residential area is no longer how to reduce noise in residential but also how to regulate the type of sound based on the existing sound source.

Mental health has become a concern of the World Health Organization, especially from the Sustainable Development goal 3.4 related to mental health and well-being. They are argued that without...
good mental health, people feel unable or less able to carry out activities of daily living, including self-care, education, employment, and participation in social life. Mental health is also very dependent on Goals number 11, Sustainable Cities and Community, where the characteristics of the built environment and neighbourhoods where people live have impacted mental health [6, 7].

An approach to comprehend the influence of human perception on the surrounding environment is through a soundscape approach [8, 9, 10, 11]. Based on the framework of soundscape, three elements are significant in soundscape research: humans with their sense of hearing, the source of sound in their environment, and the perception that arises, as illustrated in figure 1 [12]. This approach is limited to the local community, depending on the agreement between individuals in a society. A good soundscape condition in one community can be different in another group.

![Figure 1: Soundscape framework. Adapted from International Standardization Organization [12]](image)

Therefore, this paper tries to find the relationship between existing sound sources and the mental health of residents in Indonesian settlements area. Understanding the relationship between these sound sources and evokes mental health will help planners and built environment designers create a more sustainable environment for humans.

2. Research Methodology
Soundscape researchers suggest that the acoustic environment can be investigated directly in an in-situ environment or the laboratory environment through reproduction, simulation, the composition of soundscape, or recalled in memory interviews related to past environmental conditions [13, 14, 15]. Each acoustic environment needs its tools and protocols in collecting data. The most realistic data is by assessing the in-situ environment through the questionnaire. Due to the SARS-CoV2 pandemic, the perception about the area of their surrounding settlements was assessed by an online questionnaire.

Total respondents who participated in this research are 402, consisting of 42.8% male and 56.2% female. All respondents are over 17 years old, with the most extensive demographic between 25 - 60 years. Respondents who participated came from various major cities in Indonesia, as shown in figure 2.

The respondent covers variation characteristics of the Indonesian settlements, where 59% live in landed houses, 35% stay in gated communities or real estate areas, and 6% live in vertical housing such as public houses or apartments.

The questionnaire is a modification from the previous questionnaire [16, 17]. The online questionnaire is divided into general questions that explore respondents' background, such as age, gender, city of domicile, occupation, and other general data. The second part is the open questions where the respondents are asked to define the sound they had apprehended in surrounding residential areas. The last part is about assessing the perception of the surrounding acoustic environment using semantic differential scales. The soundscape's perception dimensions modify from the previous soundscape
dimensions mentioned by Aletta and the International Standardization Organization: Pleasant, Calmness, Vibrant, Eventful, Softness, Relaxing, and Variant [13, 17, 18]. Semantic differential scales used 1 to 5, where the greater the number indicates the strength of that perception dimension.

| Location     | Value |
|--------------|-------|
| Bandung      | 28    |
| Denpasar     | 20    |
| Jakarta      | 57    |
| Malang       | 16    |
| Samarinda    | 86    |
| South Tangerang | 44  |
| Tenggarrong  | 25    |
| Yogyakarta   | 18    |
| Others       | 108   |

**Figure 2.** City of residence of respondents

From the data collected, the first analysis tested is the validity of the data. Then a statistical analysis of the distribution can be carried out to determine the perceptions of their residential environment and the sound sources they can identify. Next, the statistical regression test was conducted to find significant sound sources on specific perceptual dimensions. By recognizing the impact of the sound sources on human perceptions, the environmental area in Indonesia can be commanded to improve the health of its residents.

3. Result and Discussion

Based on the reliability test, 97% of the data collected were valid, with Alpha Cronbach's .813 for seven items measured on semantic differential scales. Therefore, this data has strong reliability to describe the perception of the acoustic environment.

3.1. An overview of perception dimension in Indonesian settlements area and identified sound sources.

Based on the online questionnaire, the average value of the perception dimension in the Indonesian settlements is depicted in figure 3. Pleasant describes the respondent's condition whether they feel comfortable or uncomfortable in their residential environment. Calmness describes conditions in a frenzy or calms in their residential area. The sounds that can inspire enthusiasm are categorized as vibrant, while sounds that can describe events in the surrounding environment are rated as dimension eventfulness. The loudness and softness of the voice affect the softness dimension, while the relaxing dimension describes whether the sound relaxes or not. The last perception dimension is variant which describes whether there are many sound sources or few variations of the sound they hear.
Based on the semantic differential scales questionnaire data, respondents felt comfortable (score 3.59 out of 5) in the environment around their residence, although the conditions in each city might be different. Respondents rated the level of calmness in their settlements as relatively calm (score 3.50 out of 5) and vibrant (score 3.32 out of 5). The sound they hear can describe events around their environment (score 3.85 out of 5). However, the softness dimension is only at 3.16 out of a scale of 5, so it can be concluded that the sound is quite loud. Although in the end, they got used to the sound, which was quite loud (relaxing score 3.50 out of 5), and the number of sounds they heard (variant score 3.55 out of 5).

Figure 3. Perception dimension in the Indonesian settlement area

Figure 4. Distribution of identified sound sources in Indonesian settlements area.
Meanwhile, respondents' sound sources can be grouped (cf. figure 4) in their settlements, dominated by motorized vehicles sound, whether vehicle engines, muffler sounds, or vehicle tires touching the road surface. In addition, the category of sound they hear a lot is domesticated animals such as cats, dogs, rats. Some areas can still hear the sound of wild animals or nocturnal animals. Human voices and their activities are the third of the sounds they can identify in residential areas. Several respondents identified the sound of construction and non-transportation machines, which were grouped as electromechanical sounds. Only a few of the respondents can identify signals and natural sounds around their dwellings.

3.2. The influence of sound sources on the perception of the residents

Sound sources that affect the perception of comfort

The regression analysis shown in table 1 shows that the comfort dimension is strongly influenced by motorized sound. Perception of comfort is also significantly influenced by animals, human voices and activities, and natural sounds contribute to this. Motor vehicles in Indonesia, especially two-wheeled vehicles, are often a symbol of the social status in question. Therefore, many two-wheeled motorized vehicles are modified to improve their social status among the community. Unfortunately, this reduces the comfort of residents in the surrounding environment.

Most respondents mentioned the shrill sound of motorized vehicles as an inconvenience. This condition also affects other perceptual dimensions, which will be discussed next. In addition, with the density of big cities in Indonesia, the sound of activities from neighbours or developments in densely populated areas often disturbing hearing comfort. Regression analysis also shows that animal sound and natural sound affect comfort in the residential environment.

Table 1. The group of sound sources that affect the perception of pleasant

| Term                     | Estimate | Std Error | t Ratio | Prob>|t| |
|--------------------------|----------|-----------|---------|-------|
| Intercept                | 0.0403807| 0.04614   | 0.88    | 0.3820|
| Signal Sound             | -0.056373| 0.047081  | -1.20   | 0.2319|
| Human Sound Biased       | -0.100265| 0.046542  | -2.15   | 0.0318*|
| Electromagnetic Sound    | 0        | 0         | .       | .     |
| Motorized Sound          | -0.258051| 0.049989  | -5.16   | <.0001*|
| Animal Sound             | 0.1645241| 0.047361  | 3.47    | 0.0006*|
| Natural Sound            | 0.0960846| 0.047358  | 2.03    | 0.0432*|

Sound sources that affect the perception of calm

As previously discussed, motorized vehicles' loud and shrill sound affects the perception of calmness in residential areas, as shown in table 2. In addition, many retail areas are freely located in residential areas. On the one hand, the existence of the retail area helps the surrounding residents with their daily needs, but on the other hand, the existence of the retail also attracts other visitors using two-wheeled motorized vehicles, which in turn will affect the perception of calmness.

Table 2. The group of sound sources that affect the perception of calmness

| Term                     | Estimate | Std Error | t Ratio | Prob>|t| |
|--------------------------|----------|-----------|---------|-------|
| Intercept                | 0.0211681| 0.048324  | 0.44    | 0.6616|
| Signal Sound             | -0.045256| 0.04931   | -0.92   | 0.3393|
| Human Sound Biased       | -0.078611| 0.048744  | -1.61   | 0.1076|
| Electromagnetic Sound    | 0        | 0         | .       | .     |
| Motorized Sound          | -0.190877| 0.052355  | -3.65   | 0.0003*|
| Animal Sound             | 0.1120956| 0.049602  | 2.26    | 0.0244*|
| Natural Sound            | 0.069305 | 0.049599  | 1.40    | 0.1631|
Sound sources that affect the perception of vibrant

Besides the sound of motorized vehicles, human voices and human activities are considered a source of sound that inspires vibrant negatively. Meanwhile, animal sounds are often seen as positive, uplifting sounds, as shown in table 3.

Table 3. The group of sound sources that affect the perception of vibrant

| Term                      | Estimate  | Std Error  | t Ratio | Prob>|t| |
|---------------------------|-----------|------------|---------|-----|
| Intercept                 | 0.0271095 | 0.046933   | 0.58    | 0.5639 |
| Signal Sound              | 0.0159798 | 0.047691   | 0.33    | 0.7388 |
| Human Sound Biased        | -0.17254  | 0.047342   | -3.64   | 0.0003* |
| Electromagnetic Sound Zeroed | 0         | 0.0        |        |    |
| Motorized Sound           | -0.183391 | 0.050848   | -3.61   | 0.0004* |
| Animal Sound              | 0.1575127 | 0.048175   | 3.27    | 0.0012* |
| Natural Sound             | 0.04162   | 0.048172   | 0.86    | 0.3881 |

Sound sources that affect the perception of eventful

The most dominant factor on the perception of eventful is motorized vehicles, which are shown in table 4. As previously discussed, motorized vehicles often indicate social status in Indonesia. So that motorized vehicles are often modified to show personal identity. Thus, hearing the sound of certain motorized vehicles can describe the situation around the residential environment. In addition, there are lots of street sellers in residential areas, which can be easily identified by the sound they hear.

Table 4. The group of sound sources that affect the perception of eventful

| Term                      | Estimate  | Std Error  | t Ratio | Prob>|t| |
|---------------------------|-----------|------------|---------|-----|
| Intercept                 | 0.0254669 | 0.048154   | 0.53    | 0.5972 |
| Signal Sound              | -0.025803 | 0.049136   | -0.53   | 0.5998 |
| Human Sound Biased        | -0.106518 | 0.048573   | -2.19   | 0.0289* |
| Electromagnetic Sound Zeroed | 0         | 0.0        |        |    |
| Motorized Sound           | -0.258917 | 0.052171   | -4.96   | <.0001* |
| Animal Sound              | 0.017087  | 0.049428   | 0.35    | 0.7298 |
| Natural Sound             | 0.0898061 | 0.049425   | 1.82    | 0.0700 |

Sound sources that affect the perception of softness

Table 5 shows the sound sources that negatively affect the level of loudness and softness, namely motor vehicles and the sound of humans and activities carried out by humans in the residential environment. By modifying motorized vehicles, especially two-wheelers, by making the muffler sound louder and shrill, harms the perception of softness in the area of their settlements. In addition, the hustle and bustle of human activities in dense residential areas also affect the perception of the sound calmness level that needs to be reduced in residential areas.

Table 5. The group of sound sources that affect the perception of softness

| Term                      | Estimate  | Std Error  | t Ratio | Prob>|t| |
|---------------------------|-----------|------------|---------|-----|
| Intercept                 | 0.0254669 | 0.048154   | 0.53    | 0.5972 |
| Signal Sound              | -0.025803 | 0.049136   | -0.53   | 0.5998 |
| Human Sound Biased        | -0.106518 | 0.048573   | -2.19   | 0.0289* |
| Electromagnetic Sound Zeroed | 0         | 0.0        |        |    |
| Motorized Sound           | -0.258917 | 0.052171   | -4.96   | <.0001* |
| Animal Sound              | 0.017087  | 0.049428   | 0.35    | 0.7298 |
| Natural Sound             | 0.0898061 | 0.049425   | 1.82    | 0.0700 |
Sound sources that affect the perception of relaxing

There is an indirect relationship between quiet-noise and loud-soft with relaxing and comfort based on the sound source component, as illustrated in table 6. Most respondents stated that they did not feel relaxed in their residential area with the existing noise and loudness level. Sound sources that influence the perception of this noise are human voices and activities by humans and the sound of motorized vehicles. Animal sounds play a significant role in creating a relaxing perception.

Table 6. The group of sound sources that affect the perception of relaxing

| Term                    | Estimate  | Std Error | t Ratio | Prob>|t|
|-------------------------|-----------|-----------|---------|------|
| Intercept               | 0.029519  | 0.047235  | 0.62    | 0.5324 |
| Signal Sound            | 0.0305941 | 0.048198  | 0.63    | 0.5260 |
| Human Sound Biased      | -0.167456 | 0.047646  | -3.51   | 0.0005* |
| Electromagnetic Sound Zeroed | 0         | 0         | 0       | .     |
| Motorized Sound         | -0.242319 | 0.051175  | -4.74   | <.0001* |
| Animal Sound            | 0.1135455 | 0.048485  | 2.34    | 0.0197* |
| Natural Sound           | 0.0845455 | 0.048481  | 1.74    | 0.0820 |

Sound sources that affect the perception of variant

There is no specific sound source that affects the variant, as shown in table 7. In other words, all these sound sources contribute to the variation of the sound heard.

Table 7. The group of sound sources that affect the perception of variant

| Term                    | Estimate  | Std Error | t Ratio | Prob>|t|
|-------------------------|-----------|-----------|---------|------|
| Intercept               | 0.0113368 | 0.049953  | 0.23    | 0.8206 |
| Signal Sound            | 0.0147161 | 0.050972  | 0.29    | 0.7730 |
| Human Sound Biased      | -0.050598 | 0.050388  | -1.00   | 0.3159 |
| Electromagnetic Sound Zeroed | 0         | 0         | 0       | .     |
| Motorized Sound         | -0.004034 | 0.05412   | -0.07   | 0.9406 |
| Animal Sound            | 0.0181651 | 0.051274  | 0.35    | 0.7233 |
| Natural Sound           | 0.0141541 | 0.051271  | 0.28    | 0.7826 |

4. Concluding Remarks

Based on the research results above, three groups of sound sources affect almost the overall perception of the residential environment: a motorized sound that covers engine sound, exhaust sound, and horn sound, human sound involves human voice and activity, and animal sounds. Motor vehicle noise and human voices, which cover human noise and activities, negatively affect all perceptions of the residential environment. While the sound of animals positively affects the overall perception of the residential environment.

Previous qualitative research also concluded that the sound of motorized vehicles dominates the soundscape in Indonesia [19]. This quantitative research confirms that motorized vehicles are the most significant impact on the perception of the residential environment. Motorized vehicles often became an identity for some Indonesian people. Therefore, they are often modified to stand out in the community, as seen in the eventful value. The modifications are often made to amplify and shrill the muffler sound, which causes the disturbing sound to the perception of calmness, softness, relaxation, and comfort.

The government has tried to reduce the noise from this vehicle sound by a regulation. The maximum sound pressure level for motorcycles is limited to 83 dB [20], but this standard is still above the noise limits for residential areas, which is 55dB [21]. Therefore, the government needs to enforce the rules to limit the noise level in this residential area. Another related issue to this is the existence of small retailers in residential areas. The purpose of small retailers is to suffice the daily needs of residents becomes easier.
Nevertheless, this becomes an obstacle when it is associated with the social situation in Indonesia. Frequently, motorized vehicles are still in use even within a walking distance radius. Therefore, the presence of these retailers in residential areas needs to be re-considered to reduce the use of motorized vehicles in residential areas.

Another influential group of voices is the human voice and human activity, especially in areas with high density in urban areas. Local music is played too loud, reducing the perception of comfort, calmness, and relaxation in residential areas. Therefore, it must be a mutual agreement between residents. Through this research, the sound sources in the residential environment in Indonesia can be identified as their influence on human perception in the settlement areas. This study suggests the arrangements for these sound sources in Indonesia's residential areas to bring the residents' sustainable environmental health.

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