SHORT COMMUNICATION

Relationship Analysis between Vegetation and Traffic Noise Pollution: A Case Study of Lahore, Pakistan

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Introduction

Development in urban transportation is increasing day by day. The use of transportation in terms of vehicles makes noise which causes several adverse effects on the health of the masses (Monazzam et al., 2015). The problem of traffic noise pollution is rapidly increasing day by day and is closely associated with the rapid industrialization and urbanization taking place over the globe (Margaritis and Kang, 2016). The reduced effects of vegetation cover on the propagation of sound have been the theme of much debate for several years (Bell et al., 2007). However, there is increasing evidence that it is not always true and a significant reduction of noise may be accomplished through vegetation cover if present in adequate density and depth (Peng et al., 2014). Noise pollution is noticeably dangerous for human health and the environment (Selander et al., 2009; Maqsood et al., 2019) that adversely affects the quality of the environment. It develops aggressiveness in public which leads to higher blood pressure. It also increases the stress level. It is said that 65 dB of routine contact with noise can cause hypertension. Whereas the level of noise above 75 dB can cause stress, heart diseases, and hearing loss (Doygun and Gurun, 2008). In recent years, noise pollution is achingly disturbing the quality of life particularly in cities. Traffic noise has eminently become a very serious issue. It causes health issues including mental health that leads to annoying behaviour of citizens. The decisive skill of people is also negatively affected. Thus, it completely disturbs the quality of life where traffic is the major cause of noise pollution. In 2015, Abbaspur et al. evaluated the traffic noise pollution in Karachi which is the megacity of Pakistan, here the noise pollution rate is higher in morning and evening slots due to the traveling pattern of residents in this city (Abbaspur et al., 2015). The case study area, Lahore is the second largest metropolitan city of Pakistan in terms of population and traffic after Karachi (GoP, 2017). The total area of Lahore is 1,772 square kilometers (Nasar-u-Minallah, 2019), and the road network length is more than 2,000 kilometers. The rapid growth of population and road traffic in the metropolitan city has put excessive pressure on the road network and the traffic volume on the roads and intersections has reached a saturation point (NESPARK, 2004; Zia et al., 2021). In Lahore city, noise pollution of traffic is very common due to low maintenance quality and vehicle honks, etc. The distinctive automobiles of the Lahore Metropolitan City’s vehicle population are buses, vans, trucks, motorbikes, and three-wheel vehicles which are mostly driven by two-stroke engines.

Study Area

The main Walton and Mall road areas were selected as a case study area, situated in Lahore (Fig.1). Lahore lies between 31°15’-31°43’ N and 74°10’-74 °39’ E (Nasar-u-Minallah, 2020). These areas are significant in their culture and are common commercial areas along with important roads providing access to CBD from the inner cities of Lahore. These areas are located near Ferozepur Road, Bedian Road, Jail Road, and Lahore Zoo. Mall road is located in Gulberg town and Data Gunj Baksh town while Walton road is located in cantonment. Walton road lies in UC 152.

Fig. 1 Depicting the case study area; Walton and Mall roads.
Materials and Methods

Primary noise data were collected from Walton and Mall Road, Lahore. For random sampling using GPS total of 10 locations were selected. The primary data on the noise level was collected by using a sound level meter (JTS-1357) as well as a mobile application. The sound meter of several vehicles was also calculated. Noise data were collected in the morning and evening times on the same sample sites to draw the comparison of noise levels during different time intervals with traffic flow. Data were collected in April 2019 at 10:00 am to 12:00 pm and 4:00 pm to 6:00 pm for morning and evening respectively. Data were collected on weekends i.e. Saturday and Sunday. Relationships between noise pollution and vegetation cover of the surrounding environment were also identified using descriptive statistics and deriving NDVI (Normalized Difference Vegetation Index) values for selected sample points. In this study, one satellite image for the year 2019 of Landsat-8 OLI-TIRs is acquired with Path: 149 and Row: 38. The acquired Landsat satellite image has been first pre-processed as radiometric and geometrically corrected for the image enhancement and then extracted by mask according to the boundary of the selected case study area of Lahore. Then, the analysis of the NDVI was performed to identify the percentage ratio of green cover in the selected case study area. Spatial analysis of NDVI has been executed with the following equation:

\[
\text{NDVI} = \frac{(\text{NIR} - \text{RED})}{(\text{NIR} + \text{RED})}
\]

Scatter plots have been generated to show the correlation of the number of vehicles per hour and noise level. Later, vegetation cover and noise level have also been assessed using scatter plots and exhibiting its correlation.

Results and Discussion

Traffic flows at Walton and Mall roads

Ten observation points for traffic measurement have been taken at both Walton and Mall roads. The highest traffic flow was found at Walton road Qainchi bridge, where heavy traffic operates throughout the day. One of the obvious reasons for the high noise level at this location is that the Qainchi point is the busiest interaction of Feroz Pur road, model Town, and Walton road. Among 10 traffic measurement locations at both Walton road and Mall roads, daily maximum average traffic flow per hour was found at Walton road on Qainchi Bridge. Figure 2 shows the highest concentration of traffic flow was found at Qainchi Bridge which is 241 traffic counts per hour as compared to others. The second highest traffic flow was found at Dolphin Headquarter which is 240 vehicle flow/hr. The lowest concentration of traffic flow was found at R.A Bazar which is 161 vehicle flow/hr.

Mall road was found to be a less polluted site as compared to Walton road. From the result of a survey conducted during 8 days of data collection, the result shows the less concentration of noise level at Mall road as compare to Walton road. Figure 4 shows the highest concentration of traffic flow was at Qazi center which is 186 traffic counts per hour. The second highest traffic flow was found at PC hotel which is 184 traffic flow/hr and the lowest concentration of traffic flow was found at the upper mall scheme (Fortress bridge) which is 163 vehicle flow/hr.

Noise Fluctuations at Walton and Mall roads

Figure 3 shows the high concentration of noise level in R.A Bazar. R.A Bazar was emitting the high value of noise level (76.06 dB) as compared to others. The second highest consternation of noise level was Koray. The observed average noise level was 76.06 dB. However maximum and minimum noise level is 86.68 and 49.29 respectively. It showed that 100% of noise measurement locations are exposed to the
higher noise level. Even though the daily average minimum noise level at all locations is more than 45 dB, which reflects the aggravated problem of noise on the roadsides of Lahore city. The highest maximum noise level 89 dB was found near Qainchi Bridge, from where traffic passes at all times of the day and night.

Figure 5 shows the high concentration of noise level in Mall road. The Townhall was emitting a high value of noise level (73.11 dB) as compared to others. However, the maximum and minimum noise levels are 85.42 and 45.69 respectively. It showed that 100% of noise measurement locations are exposed to the higher noise level. Even though the daily average minimum noise level at all locations is more than 45 dB, which reflects an aggravated problem of noise on the roadsides of Lahore city. Upper Mall scheme and Qazi center were emitting less concentration of noise level as compared to other locations of the mall road.

**Correlation of Traffic Flows and Noise Levels**

Figure 4a shows that with every 1 decibel of noise level increases the -0.018 traffic flow decreases. There is a negative relation between traffic flow and noise level of Walton road and it is concluded that as the noise level increases the traffic flow decrease at Walton road.

| Traffic flow/hr | Noise level dB |
|----------------|---------------|
| 242            | 74.98         |
| 241            | 74.52         |
| 215            | 73.31         |
| 192            | 75.52         |
| 162            | 76.06         |

**Traffic flow/hr. and noise level (dB) on Mall road, Lahore**

| Traffic flow/hr | Noise level dB |
|----------------|---------------|
| 164            | 70.3958       |
| 184            | 72.583        |
| 173            | 72.875        |
| 186            | 71.935        |
| 177            | 73.1145       |

Figure 4b shows that with every 0.064 meters the traffic flow increases with 1 decibel of the noise level. There is a positive relation between Traffic flow and noise level of Mall road and it is concluded that as traffic flow increases the noise level also increases.

**Table 1 Traffic flow/ hr and noise level (dB) at Walton Road, Lahore**

| Traffic flow/hr | Noise level dB |
|----------------|---------------|
| 242            | 74.98         |
| 241            | 74.52         |
| 215            | 73.31         |
| 192            | 75.52         |
| 162            | 76.06         |

Figure 3Traffic Noise Fluctuation in Walton and Mall roads, Lahore

Fig. 4 Traffic Flow and noise correlation: a) Walton road; b) Mall road.
Impact of Vegetation on Noise Pollution

Indices are being applied to check out the vegetation cover. The threshold value of the normalized difference vegetation index is from -1 to +1. Figure 5 shows the NDVI (normalized vegetation index), which highlights the vegetation of an area. It is showing more vegetation in the Mall road than Walton Road, Lahore.

![NDVI Map](image)

Fig. 5 NDVI at Walton and Mall roads, Lahore.

There is an inverse relationship between noise level and vegetation. At Qainchi bridge, the vegetation cover is 4 hectares and the noise level are 74.98 while at Koray the vegetation cover is 3 hectares and the noise level are 75.52 dB.

**Table 2 Vegetation effects on noise at Walton road.**

| Location          | Noise Level (dB) | Vegetation (hectare) |
|-------------------|------------------|-----------------------|
| Qainchi bridge    | 74.98            | 04                    |
| Dolphin- head Quarters | 74.52            | 9.6                   |
| Railway flats     | 73.31            | 09                    |
| Koray             | 75.52            | 03                    |
| R.A Bazar         | 76.06            | 09                    |

**Vegetation effects on noise at Mall road**

| Location          | Noise Level (dB) | Vegetation (hectare) |
|-------------------|------------------|-----------------------|
| Upper Mall scheme | 70.39            | 17.3                  |
| PC Hotel          | 72.58            | 10.6                  |
| GCU-Botanical Garden | 72.87            | 8                     |
| Qazi center       | 771.93           | 3.9                   |
| Town Hall         | 773.11           | 3                     |

Figure 6a shows that every 0.01 square kilometer decrease in Vegetation will increase 0.1 decibels in noise level on Walton road. There is a positive relation between vegetation and noise level and it is concluded that a decrease in vegetation will increase noise level at Walton road. There is also inverse relation between noise level and vegetation at Mall Road i.e. at Town Hall, the vegetation cover is 3 hectares and the noise level is 73.11 while at Qazi center the vegetation cover is 3.9 hectares and the noise level is 71.93. Figure 6b shows that with every 0.83 square kilometer decrease in vegetation, increases 0.1 decibels in noise level on Mall road. There is a positive relation between vegetation and noise level and it is concluded that a decrease in vegetation will increase noise level as tested at Mall road.

![Graphs](image)

**Fig. 6 Vegetation and noise correlation: a) Walton road; b) Mall road**

**Conclusion**

The selected sample sites of Walton road are the major locations of higher noise levels due to heavy traffic. The daily maximum level of noise was 89 dB recorded. The most noise polluted site was found to be Walton road, even noisier than the Mall road. The result shows that the high concentration of noise level...
was at all sample locations of Walton road. R.A Bazar was creating the average high value of noise level (76.06 dB) as compared to other locations on Walton road and Mall road. There is a positive relationship between traffic noise level and traffic flow of both roads. Finally, it has been identified through spatial distribution of noise level that there is a strong relationship between noise level and traffic flow on both roads.

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