Evaluation of Practical Framework for Industrial Noise Mapping: A Case Study

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Abstract

Strategic noise maps are typically prepared for large-scale areas, towns and cities. However, some comparatively smaller industries are given less importance during preparation of noise maps. Very few studies have been reported worldwide providing insight on industrial noise mapping, and similar reports from India are negligible. This study provides a noise map of a forging plant and also investigates noise distribution pattern within 2 km of surrounding area. The complete study is evaluated in two types of scenario; in the first scenario all individual noise sources of the plant were considered as point sources whereas in the second scenario complete plant was treated as an area source. Furthermore, a regression graph is generated between the predicted and measured values for both scenarios individually which gives coefficients of determination of 0.4689 and 0.6382. This study reveals that the second scenario provides more precise noise prediction map than the first scenario.

Keywords: Area source, industrial noise mapping, noise pollution, point source, strategic noise mapping

INTRODUCTION

Noise is an undesirable sound and a growing reason of global worry, particularly in urban areas of developing and developed countries. In recent years, increasing industrialization and enormous production have intensified the noise problem around the Indian subcontinent.\(^1\) The World Health Organization (WHO) listed noise pollution in the third position after air and water while classifying most hazardous pollutants.\(^2\) Noise pollution is the result of intense human activity, usually in urban areas. In overcrowded cities occupational noise is not only limited to workers, but it also affects the nearby population. European directive for noise aims that “no person should be exposed to noise levels, which endanger health and quality of life”.\(^3\)

Increasing population and amalgamation of different noise sources are major challenges for noise level quantification and prediction in large cities. These factors are demanding researchers to carefully select the assessment method to attain desired accuracy. Strategic noise maps of major Indian cities are available, but they are based mostly on traffic-induced noise where detailing of industrial sources was neglected. In most of the Indian cities, it can be easily observed that a very large population resides in a dense manner near the plants and this makes it important to study noise generated by small-scale industries. Although classification of industries have been given by government of India on the basis of income and workforce,\(^4\) in this study small-scale industries refer to industries which are comparatively smaller in size (1,000–7,000 sq. meters) and located within the premises of city, most likely textile mills, forging and cutting division, rice mills, etc.

Noise have auditory and non-auditory health effects on humans. The evidence of the effects of high noise level on health is strongest for annoyance, sleep, mental disturbance, and raised blood pressure.\(^5\)

In 2009, Banerjee et al.\(^6\) published noise map for city of Asansol in West Bengal India. In his study only...
traffic-induced noise was considered whereas one part of the city was classified as industrial zone and there were several mixed zone areas as well; the accuracy of this kind of study can be improved by inclusion of industrial noise source. Also, the significance of honking for Indian traffic condition was studied by Kalaiselvi and Ramachandraiah.\(^7\) The number of light vehicles and of heavy vehicles has been used to evaluate the equivalent traffic density for each type of vehicles, as introduced by Agrawal and Swami.\(^8\) To measure traffic noise levels under heterogeneous traffic conditions of Indian city Jaipur, Pal et al.\(^9\) studied the noise attenuation characteristics of green belts and established multivariable linear relationship for excess noise attenuation. There is a demand for a better insight into such problems which can provide an improved result. Objectives of this study are monitoring and mapping of noise exposure levels of industrial site and to find the better way to represent source scenario, which can improve the accuracy of a strategic noise map of an entire city. Another objective of the study is to assess the industrial noise and its contribution to the overall noise environment of the study area.

**METHODOLOGY**

All measurements were carried out in and around a forging plant at Velur village in Tamil Nadu, India. This unit is located at 1.5 km away from the national highway 45B and the plant is spread on 2,788 sq. meter working area. It has facilities of open die and closed die forging with manufacturing capacities of 9,000 metric tonne per annum. There is one open die and four closed die pneumatic hammer ranging from 1 to 10 tonne and each hammer is paired with trimming press. Sound level at different points has been calculated by the method outlined in ISO 9613-2.\(^{10}\) All measurements were taken during a normal operating condition when only four hammers were working.

A digital sound level meter type 2 with frequency weighing network as per IEC specification and frequency range 6.3 Hz–20 Khz and measuring range 0–140 dB(A) was used for the study. To measure equivalent sound pressure levels of hammers (point sources) a distance of 4 m was maintained between source and receiver. Different readings in all directions out from the boundary of plants are taken and a distance of 200 meters was considered to measure the total noise emitted by plants (area source). Noise measurements were performed when the effect of noise sources of variable factors were at minimum. All data were obtained on normal working day with suitable meteorological condition like no rain.

To create noise map of study area predictor LIMA 11 was used. This software performs prediction and calculation of noise as well as the sound levels as contours. At the national

![Flow chart for industrial noise mapping](image-url)
highway 45B, measurements for traffic flow and equivalent sound pressure levels were recorded for 60 minutes. Traffic noise is considered as line source in both scenarios. All conversions of pressure level to power level were done manually using formula:\[11\]:

\[ L_W = L_P - 10 \log \left( \frac{Q}{4r^2} \right) \]

where \( L_W \) is required power level, \( L_P \) is pressure level, \( Q \) is a directivity factor and \( r \) is the distance between source and receiver in meters.

Assessment and prediction of the sound exposure levels of industrial plant are complex in nature. In an attempt to improve prediction of noise levels of forging plant and nearby area two different approaches have been considered in this study. The first approach is termed as scenario 1 where all noise sources within the plant such as forging hammer and other noise-generating equipments are considered as individual point sources whereas in scenario 2 complete forging plant represents an area source.

A general methodology for noise mapping of an industrial plant is illustrated in Figure 1. Most important part of it is to obtain the input data correctly, variation in input data affects the accuracy of the map and leads to wrong calculations of noise levels across the study area.\[12\]

RESULTS AND DISCUSSION

To investigate the compatible methodology two distinct noise prediction maps are presented here for both scenarios with the help of seven study points to highlight the noise exposure levels in the nearby areas of the forging plant. Figure 2 represents the noise prediction map for scenario 1, where H1, H2 and H3 are indicating the residential blocks situated within 500 meters from the forging plant, while other locations represent neighbouring villages. In the strategic noise map, predicted noise levels are validated using noise data registered during a measurement campaign at all locations. In this map H3 has the highest predicted noise level of 61 dB(A) whereas, at Puthupatti village the lowest level of 35 dB(A) was recorded.

Figure 3 displays the noise map of the same study area for scenario 2. The highest value of 58 dB(A) was predicted at H3 and the minimum predicted noise of 41 dB(A) level was measured at New Vellur village. It can be noticed that the highest average noise level occurs in average noise level occurs in the forging plant (>65 dB(A)) and the areas which are farthest from the plant and national highway show the lowest noise level (<40 dB(A)).

At Kullavaipatti village the measured noise level was was 50 dB(A) but in scenario 1 this point lies in green contour, that
is 0–40 dB(A) whereas, in scenario 2 it lies within 40–45 dB(A) yellow contour range. When we concentrate on yellow contour lines of both maps and compare, it is clearly visible that scenario 2 has wider yellow contour range, means high noise levels for extensive area.

Noise levels at all study points were recorded during measurement to check the accuracy of predicted results. Table 1 gives the measured and computed noise levels at different study points. In order to compare the measured and predicted results, the graphical representation in the form of scatter chart for both scenarios were derived which shows the close proximity of the predicted noise levels with the measured values.

For scenario 1 the maximum variation between predicted and measured noise level is found in the Puthupatti village of 20.7 dB(A) and minimum at H1 the nearest house from the forging plant of 1.3 dB(A), the second largest such difference can be observed in Kullavaipatti village of 12 dB(A). All other study points have this difference within 6 dB(A) range. It should be noted that the study points that have more than 10 dB(A) difference are located farthest from both the sources, that is forging plant and national highway. Figure 4 shows the relationship between predicted and measured noise levels for scenario1 and represents coefficient of determination ($R^2$) of 0.4862.

Table 1: Measured and predicted noise levels at different study points

| Sr. No. | Study points | Measured noise level in dB(A) | Predicted noise level for Scenario 1 | Predicted noise level for Scenario 2 |
|---------|--------------|-------------------------------|-------------------------------------|-------------------------------------|
| 1       | H1           | 57.3                          | 52                                  | 54                                  |
| 2       | H2           | 59.1                          | 55                                  | 57                                  |
| 3       | H3           | 56.7                          | 61                                  | 58                                  |
| 4       | Velur        | 53.6                          | 47                                  | 48                                  |
| 5       | Puthupatti   | 55.7                          | 35                                  | 43                                  |
| 6       | Kullavaipatti| 50                            | 38                                  | 42                                  |
| 7       | Kuruchipatti | 52.8                          | 49                                  | 45                                  |
| 8       | New Velur    | 45                            | 35                                  | 41                                  |

Figure 3: Noise map for scenario 2
The study point where the maximum difference was observed in scenario 2 is at Puthupatti village (12.7 dB(A)) and minimum variation between predicted and measured noise level for this scenario is found to be at H3 of 1.3 dB(A). It can be observed, just like scenario 1, the maximum variations are to be traced at study points which are located away from noise sources such as forging unit and national highway, measured noise levels at these points are more than 10 dB(A) higher than predicted noise. As all these points are located in nearby villages the reason for high variation could be the other domestic noise sources which may not be considered during the study. Figure 5 shows the scattered graph for scenario 2 with coefficient of determination ($R^2$) of 0.6362. Noise levels are considerably high in most of the residential places and nearby villages as compared to the prescribed Central Pollution Control Board of India (CPCB) limits. An area with less traffic movement shows lower noise levels. Although study area is well vegetated, the noise levels were considerably higher during the working hours, as witnessed in the course of the study.

National highway 45B joins Tiruchirappalli with Madurai, the two major cities of the state Tamil Nadu. It carries an elevated road traffic flow and accounts for moderately high noise levels in and around its nearby area. The nearby areas of the road and also the area in-between the road and forging plant can be categorized as a high noise risk zone and is important in the sense that residential establishments and schools are within 100 m radius. The coefficient of determination for scenario 1 is 0.4865 and it

![Figure 4: Scatter-plot of predicted versus measured values for scenario 1](image)

![Figure 5: Scatter-plot of predicted versus measured values for scenario 2](image)
is less than the coefficient of determination for scenario 2 which is 0.6362. However, there is not any drastic change in both maps at least at the nearby areas of sources, but it is clearly visible that for scenario 2 comparatively the wide range of yellow contour, higher coefficient of determination and also the difference between the predicted and measured values are leading to the inference that scenario 2 is providing a comparatively accurate prediction map than scenario 1.

CONCLUSIONS

Noise pollution study for industrial plant is less explored till now and very few researches have given insight on industrial noise mapping. This study clearly reveals that when a complete plant is considered as an area source, it provides better noise accuracy than treating each noise source independently for noise prediction.

Mapping of a larger area comprises all kinds of zones (industrial, commercial, silent, residential) consisting of shops, roads, rail lines and industries and would deliver better result when industries are considered as an area source. Collecting input data for scenario 1 is a difficult task and it also involves a certain level of risk. Practically while assessing sound pressure levels of point sources within any plant with several other machines that are working simultaneously, chances of variation in input data are higher.

The accuracy of prediction map at very far points from the sources are low, although this study would be helpful in future for the researchers working on industrial noise mapping as well as strategic noise mapping. Central Pollution Control Board of India has decided noise limits for four zones residential, industrial, commercial and silent. A rapidly growing population, densely populated cities and growing economic needs are merging all kinds of noise zones like industrial, commercial, silent and residential into one and it is hard to categorize many areas in the city as one of them. It would be better to call them mixed zones. There is a need in India to introduce noise limits for mixed areas which could consist of shopping complex, residential apartments and/or industrial plants and it is notable that the Portuguese government has already categorized mixed zones and imposed different noise limits for such areas.

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Conflicts of interest

There are no conflicts of interest.

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