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# Development of GIS Based Traffic Noise Map for Roorkee City

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**Abstract**

*This paper deals with collection of primary data of traffic characteristics such as traffic volume, spot speed and noise data, predicting noise by a prediction model and integrating with Geographic Information System (GIS). Noise map, contour map and land use cover map of Roorkee city was prepared using ArcGIS. The study shows that for commercial areas of Roorkee Township the Leq level is quite high as compared to the ambient national standard of 65 dBA requiring specific abatement measures. In addition sensible noise climate has been observed in areas near hospital, exceeding the standard of that for silence zone due to its proximity to the National Highway. Higher noise levels were observed in Alpahar Restaurant, IIT Roorkee and Irrigation Research Institute.*

## 1. INTRODUCTION

Road traffic noise has become a major concern of communities living in the close vicinity of major highway corridors. Noise is being recognized as a serious environmental problem, and one which must be accounted for in any development policy, which is designed to improve the quality of life of citizens. The need for efficient transportation means an increase in the modes of transportation and on the number of vehicles. As a consequence, cities face increasing noise levels. Thus there is a need for developing and drawing noise maps in urban area like Roorkee. Noise maps describe spatial distribution of noise levels. They allow an efficient visualization of the noise distributions in areas where land use is sensitive to noise. Noise mapping is very efficient noise assessments method in an urban area. For large cities, challenges have to be met in terms of data management, data reduction, calculation methods, optimization procedures, validation techniques and presentation of results so that maps as powerful tools can be used for urban noise planning and design. Noise in cities is contributed by many sources. Urban noise must be managed and controlled so that excessive noise levels do not conflict with common human activities and with peoples' perception of wellbeing.

Sound is formed by oscillations of air, which can be observed by the human ear. Humans are able to hear a sound within the frequency range of 20 Hertz (Hz) to

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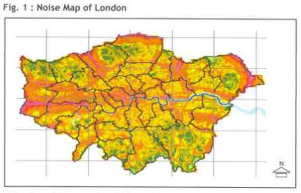
20,000 Hz. Sound is expressed in decibels i.e. dBA, which is a logarithmic scale. To the human ear a sound reduction by 10 dBA will have the approximate effect of halving the subjective noise level while reducing the sound energy with 90 percent. Faint sounds such as rustling leaves have a loudness of approximately 20 dBA and loud music, such as in a disco, of 100 dBA. Sound has multiple roles. Sound is a source of information but can also be disturbing. It can be pleasant as well as annoying. The same sound can be useful for one but unwanted for somebody else. The consequences to the health caused by noise are many as shown below:

- Loss of hearing (levels exceeding 85 dBA and a long exposure time)
- Stress related health effects like hypertension, cardiovascular problems and influence on birth weights
- Sleep disturbance (Kluijver and Stoter, 2003).

## 2. RESEARCH REVIEW

Pamanikabud(2010) analyzed the impact of traffic noise on the high-rise buildings and surrounding areas by the side of a new motorway that links Bangkok to the new Suwannaphum International Airport and Pattaya. In this study traffic noise simulation model in 3D form is applied on a GIS system. Visualized noise levels are formulated in vectored contours for noise mapping on all surfaces of the building and surrounding ground in a 3D platform. Noise impact is then investigated based on this 3D noise mapping in LAeq1h noise contours. Rajkumara et al (2008) presented a review on various traffic noise studies and the number of traffic noise prediction models cited in literature reveals that they describe the temporal and spatial distribution of traffic noise. Most of these models are either deterministic or statistical in nature. Some of these models are FHWA, Calculation of Road Traffic Noise, etc. Department for Environment, Food and Rural Affairs (DEFRA), London gave report describing the London Road Traffic Noise Map. It provides

Fig. 1 : Noise Map of London



*Note : The different colors indicate different noise level.*

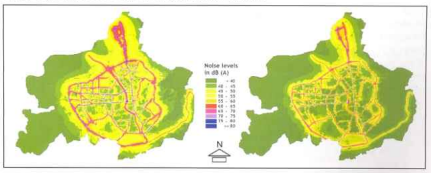
information on the data sources that were used, the data processing that was involved, and the methodology used. Producing a strategic road traffic noise map for the Greater London area - the largest such map in the UK. Results have been obtained which show the road traffic noise impact on London city, the numbers of people affected and where they are located.

Ko et al (2011) prepared a scheme to develop a noise map and noise impact assessment method using GIS. After developing a road-traffic noise map for the city of Chungju, Republic of Korea, noise impact assessment was performed through analyzing the map.

### 3. THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000

In India the principal rules were published in the Gazette of India vide S.O. 123(E) dated 14 February 2000 and subsequently amended vide S.O. 1046(E) dated 22 November 2000, S.O. 1088(E) dated 11 October 2002, S.O. 1569 (E) dated 19 September 2006 and S.O. 50 (E) dated 11 January 2010 under the Environment (Protection) Act, 1986. Whereas the increasing ambient noise levels in public places from various sources including industrial activity, construction activity, fire crackers, sound producing instruments, generator sets, loud speakers, public address systems, music systems, vehicular horns and other mechanical devices have deleterious effects on human health and the psychological wellbeing of the people, it is considered necessary to regulate and control noise producing and generating sources with the objective of maintaining the ambient air quality standards in respect of noise. Central government has made the following rules for the regulation and control of noise producing and generating sources, namely:

Fig. 2 : Noise Map for tThe City of Chungju, Republic of Korea








- The ambient air quality standards in respect of noise for different areas/ zones shall be such as specified in the Schedule annexed to these rules.
- The State Government shall categorize the areas into industrial, commercial, residential or silence areas/zones for the purpose of implementation of noise standards for different areas.
- The State Government shall take measures for abatement of noise including noise emanating from vehicular movements, blowing of horns, bursting of sound emitting firecrackers, use of loud speakers or public address system and sound producing instruments and ensure that the existing noise levels do not exceed the ambient air quality standards specified under these rules.
- All development authorities, local bodies and other concerned authorities while planning developmental activity or carrying out functions relating to town and country planning shall take into consideration all aspects of noise pollution as a parameter of quality of life to avoid noise menace and to achieve the objective of maintaining the ambient air quality standards in respect of noise.
- An area comprising not less than 100 meters around hospitals, educational institutions and courts may be declared as silence area/zone for the purpose of these rules.
- The noise levels in any area/zone shall not exceed the ambient air quality standards in respect of noise as specified in the Schedule.
- The authority shall be responsible for the enforcement of noise pollution control measures and the due compliance of the ambient air quality standards in respect of noise.
- The respective State Pollution Control Boards or Pollution Control Committees in consultation with the Central Pollution Control Board shall collect, compile and publish technical and statistical data relating to noise pollution and measures devised for its effective prevention, control and abatement after obtaining written permission from the authority.
- A loud speaker or a public address system or any sound producing instrument or a musical instrument or a sound amplifier shall not be used at night time except in closed premises for communication within, like auditoria, conference rooms, community halls, banquet halls or during a public emergency.
- The noise level at the boundary of the public place, where loudspeaker or public address system or any other noise source is being used shall not exceed 10 dBA above the ambient noise standards for the area or 75 dBA whichever is lower.

- The peripheral noise level of a privately owned sound system or a sound producing instrument shall not, at the boundary of the private place, exceed by more than 5 dBA the ambient noise standards specified for the area in which it is used.
- No horn shall be used in silence zones or during night time in residential areas except during a public emergency.
- Sound emitting fire crackers shall not be burst in silence zone or during night time.
- Sound emitting construction equipment shall not be used or operated during night time in residential areas and silence zones. The ambient noise levels recommended by the Indian Polluted Control Committee appointed by Pollution Control Board, Government of India in Table 1.

Table 1: Ambient Air Quality Standards in respect of Noise

| Category of Area/Zone | Limits of Leq (Daytime) | Limits of Leq (Nighttime) |
|---|---|---|
| Industrial area | 75 | 70 |
| Commercial area | 65 | 60 |
| Residential area | 55 | 50 |
| Silence Zone | 50 | 45 |

Note:-

- Day time shall mean from 6.00 a.m. to 10.00 p.m.
- Night time shall mean from 10.00 p.m. to 6.00 a.m.
- Silence zone is an area comprising not less than 100 meters around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority
- Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

## 4. THE STUDY AREA AND RESEARCH DESIGN

Roorkee has its importance as a premier institutional town in India. The township has an area of 8.113 sqkm and is expanding at a faster rate to cope with the increasing population. The average growth rate of its population is about 30percent per decade. Trend of population growth in Roorkee is depicted in Table 2. The growth pattern of the township exhibits irregular development of roads, lanes, residential colonies, commercial establishments and community centers at different localities which leads to consequent growth of noise sources. Increasing traffic flow volume on national highway passing through the township and frequent congestion of vehicles on busy roads and near transportation centers also add to the sensitive noise environment in their vicinity. Use of individual power generating sets in commercial houses during power cut periods lead to noise level beyond tolerable limits. The noise mapping for Roorkee Township is





essential to provide the base to the planner for proper land use planning. Further, proper legislation for planned growth of different localities can be implemented considering noise map as one of the criteria.

### 4.1 Processing of Toposheet

Preliminary step for the commencement of study is the acquisition of topographic maps for the above mentioned study area from the Survey of India. The toposheet number 53G/13 of 1:50,000 scale was acquired. The toposheet was geometrically rectified accurately with a projection system as:

Projection Type : Universal Traverse Mercator (U T M)
Spheroid Name : WGS 84
Datum Name : WGS 84
Zone : 43

Table 2 : The Trend of Population Growth in Roorkee

| Year | Population |
|---|---|
| 1971 | 47561 |
| 1981 | 61851 |
| 1991 | 80236 |
| 2001 | 97516 |
| 2011 | 11 8188 |

Advantage of using UTM projection is that all the topo-sheet can be mosaicked. The UTM keeps the coordinate systems in metric units, therefore for engineering projects the measurements of distances and calculations of areas are relatively more accurate and easier. Geo-referenced topo-sheets have been subset using AOI (area-of-interest) tool of ERDAS 9.1 software, to extract the area of study.

### 4.2 Selection of Noise Monitoring Location

A reconnaissance survey was carried out for selecting the area and to identify the locations prior to the actual noise monitoring. The land use map of Roorkee was kept alongside during reconnaissance survey to pinpoint the selected points on the map. Nineteen locations were selected for actual noise monitoring within the prime urban areas of Roorkee covering almost all land uses at specific locations. The points selected in different areas are shown in Table 2 and their locations are depicted in Fig. 6 on the map of Roorkee.

The noise monitoring points were so selected that they fully represent the prevailing noise environment of the locality in the existing land use. In the selection of monitoring points, due care was taken to avoid the effect of large physical barriers. In residential areas, the points were taken on the lane or byelane approximately in the central location of the area so that the effect of traffic noise from the adjacent prime traffic corridor is minimized. For commercial areas, the monitoring points were chosen at close proximity of high commercial activities. In institutional area, the monitoring points were taken at the open spaces either in the lawn or near the entry gate of concerned institutes. The central location surrounded by industrial sheds was selected in case of industrial estate. Exact latitude and longitude was measured using GPS to get location of different noise monitoring points so that it can be shown on map.

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Table 3 : Location of Different Noise Monitoring Points in Roorkee

| LOCATION | LANDUSE | LATITUDE | LONGITUDE |
|---|---|---|---|
| Azad Nagar | Commercial | 29°52'13.92" | 77°52'33.80" |
| Ramnagar | Commercial | 29°52'23.62" | 77°52'36.82" |
| Near Hospital | Silence | 29°52'46.35" | 77°52'36.31" |
| Sabji Mandi | Commercial | 29°52'36.17" | 77°53'16.98" |
| Rajputna | Residential | 29°52'42.89" | 77°53'03.44" |
| Sheikh Puri | Commercial | 29°51'56.93" | 77°52'43.4" |
| Near Railway Station | Residential | 29°51'25.44" | 77°52'50.11" |
| PWD | Residential | 29°52'21.11" | 77°53'45.51" |
| Petrol Pump (Canal) | Commercial | 29°52'28.70" | 77°53'21.04" |
| Malviya Chowk | Commercial | 29°51'41.35" | 77°53'8.13" |
| Khanjarpur | Silence | 29°52'03.75" | 77°54'8.28" |
| Alpahar(IIT Campus) | Silence | 29°51'51.01" | 77°53'46.17" |
| HP Gas Station | Commercial | 29°51'41.11" | 77°53'20.01" |
| Bus Stop | Commercial | 29°51'51.67" | 77°53'21.45" |
| Century Gate | Commercial | 29°52'6.79" | 77°53'23.27" |
| Haridwar Road | Commercial | 29°52'36.47" | 77°53'54.59" |
| Saraswati Mandir | Silence | 29°52'0.679" | 77°53'53.07" |
| Telephone Exchange | Commercial | 29°52'27.72" | 77°53'8.13" |
| IRI | Silence | 29°52'4.50" | 77°53'7.50" |

### 4.3 Traffic Volume Study

Volume data was obtained at all 19 noise monitoring locations for seven different categories of vehicles including car, bike, auto, bus, minibus, truck, and tractor. The data was collected between 1,600 to 1,800 hours per day. Traffic volume data was obtained for 15 minute periods. 6.4

### 4.4 Traffic Speed Study

Fig. 3 : Speed Measurement by Radar Gun

Speed data was obtained at all 19 noise monitoring locations for seven different categories of vehicles including car, bike, auto, bus, minibus, truck, and tractor. The data was collected between 1,600 to 1,800 hours per day. Traffic volume data was obtained for 15 minute periods.

### 4.5 Noise Study

Noise data was obtained at all 19 noise monitoring locations. The data was collected between 1,600 to 1,800 hours per day. Noise data was obtained for 30 second periods.



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## 5. DATA ANALYSIS AND RESULTS

### 5.1 Variation of Instantaneous Noise Levels on Different Locations

Variation of instantaneous noise levels on different locations are presented in different graphs. Observed noise levels during the sampling period were found to exhibit extremely variable nature with respect to time. Monitory rise in noise levels were observed due to the sound from honking of vehicle and other noise generating activities.

### 5.2 Noise Parameter

A total number of 4,760 discrete noise level data were collected during course of noise monitoring over a period of two months at the selected locations. Hourly energy equivalent noise levels (Leq) were computed using equation 5.1

For discrete sound levels, the value of Leq is expressed as

$$Leq = 10\left(\sum_{i=1}^{n} fi \quad 10^{Li/10}\right) \quad \text{.....5.1}$$

From the instantaneous data different noise parameters are calculated

Table 4 : The Hourly Energy Equivalent Noise Levels ($L_{eq}$)

| Location | $L_{eq}$ 4:00-4:15pm | $L_{eq}$ 4:15-4:30pm | $L_{eq}$ 4:30-4:45pm | $L_{eq}$ 4:45-4:15pm | $L_{eq}$ 5:00-5:15pm | $L_{eq}$ 5:15-5:30pm | $L_{eq}$ 5:30-5:45pm | $L_{eq}$ 5:45-6:00pm |
|---|---|---|---|---|---|---|---|---|
| Azad Nagar | 80.48 | 84.34 | 77.95 | 78.89 | 81.51 | 83.74 | 85.00 | 81.12 |
| Ramnagar | 86.03 | 84.93 | 82.61 | 83.15 | 84.80 | 86.72 | 90.07 | 87.50 |
| Near Hospital | 80.76 | 79.61 | 83.97 | 79.33 | 76.57 | 80.45 | 83.50 | 85.21 |
| Sabji Mandi | 89.49 | 89.42 | 87.43 | 78.60 | 82.73 | 86.36 | 88.92 | 86.23 |
| Rajputna | 79.33 | 82.45 | 82.57 | 76.96 | 78.79 | 78.18 | 81.24 | 86.59 |
| Sheikh Puri | 73.01 | 79.71 | 76.93 | 81.58 | 80.63 | 80.57 | 75.63 | 75.92 |
| Near Railway Station | 71.34 | 79.37 | 72.08 | 71.74 | 71.48 | 72.65 | 74.53 | 74.26 |
| Pwd | 71.73 | 73.00 | 75.87 | 76.04 | 79.85 | 69.91 | 70.43 | 71.72 |
| Petrol Pump(Canal) | 78.10 | 76.94 | 75.03 | 77.61 | 75.38 | 75.38 | 78.67 | 73.29 |
| Malviya Chowk | 80.49 | 83.75 | 81.66 | 81.94 | 84.74 | 83.83 | 86.60 | 85.11 |
| Khanjarpur | 68.87 | 74.18 | 69.45 | 67.18 | 67.74 | 70.15 | 70.53 | 72.20 |
| Alpahar(Iit Campus) | 67.58 | 71.44 | 70.28 | 71.33 | 67.56 | 68.29 | 69.19 | 67.12 |
| Hp Gas Station | 76.07 | 75.82 | 76.06 | 76.11 | 74.95 | 74.45 | 74.65 | 74.91 |
| Bus Stop | 87.86 | 86.75 | 88.91 | 86.69 | 83.35 | 81.29 | 81.77 | 85.76 |
| Century Gate | 85.29 | 80.48 | 87.34 | 78.61 | 90.50 | 80.16 | 87.77 | 83.49 |
| Haridwar Road | 74.50 | 78.40 | 80.59 | 84.29 | 82.16 | 82.35 | 81.07 | 82.39 |
| Central Library(Iit) | 68.45 | 69.21 | 67.72 | 70.43 | 66.62 | 68.54 | 64.35 | 63.76 |
| Telephone Exchange | 75.65 | 74.09 | 76.06 | 75.49 | 76.03 | 75.33 | 73.12 | 75.25 |
| Irrigtion | 74.81 | 74.93 | 82.11 | 76.45 | 78.88 | 81.07 | 79.93 | 77.44 |

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### 5.3 Development of Noise Map

Following operation was done to develop noise map of Roorkee city in ArcMap.

Step 1 Data Formatting

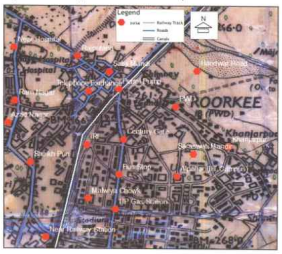
Data has been specifically formatted prior to adding the X, Y coordinates to the map. Starting with an excel spreadsheet data has been saved directly to a text or CSV file with minimal effort. Simply ensuring that first row contains column headings. Column names have been kept as simple as possible (less than 10 characters, no spaces or special characters), Ensuring that all of data is in its corresponding column and checking that coordinate values are numeric. This is very important - latitude and longitude values must be in decimal degrees. Data has been entered in DMS (degrees, minutes, seconds) format, therefore it is converted to DD(decimal degrees). For example, latitude and longitude values are given as 44° 15' 20", 78° 33' 10" respectively, these values is converted to 44.255556, 78.552778. The conversion formula is as follows:

Decimal Degrees = Degrees + ((Minutes / 60) + (Seconds / 3600))

Step 2 Adding X, Y Data to ArcMap

X, Y coordinates describe discrete locations on the earth's surface, and are collected using GPS devices. Once the information has been uploaded from the GPS to a computer, it is possible to map these points in the ArcGIS environment. In order to do so, the data must first be formatted to allow the software to read the coordinates of each point. ArcMap accepts a number of different formats, including DBF, delimited text, and CSV (comma-separated value) files.

Fig. 4 : XY Data Appeared as Points on Map




Step 3 Exporting Data to a Shapefile

Although the X, Y data is visible on map document, it has limited functionality due to the absence of an Object ID field in



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the attribute table. The Object ID field is an automatically generated key that is maintained by ArcGIS and guarantees that each row in a table has a unique identification number. The field is essential to perform key functions in ArcGIS. After right-clicking the events layer name in the TOC and export data is chosen. In the dialog box, folder button is clicked to browse to directory; at last OK button is clicked

Step 4 Adding Noise Data to Attribute Table

Attributes which describe qualities associated with features are stored in tables. Data attribute type and field properties such as precision, scale, or length must be specified when creating fields for the attribute table of a new Shapefile or when adding a new field to the attribute table for an existing Shapefile. The choice of attribute data type and associated settings affect storage and display and can have serious consequences for the accuracy and efficiency of the underlying database. Noise level, permissible noise level and name of location is added to the attribute table.

Step 5 Creating Contour and GIS Based Noise Map

Fig. 5 : Bar Chart showing Noise levels at Different Locations

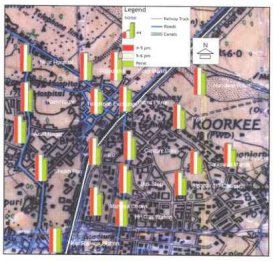



Fig. 6 : Noise Contour Map of Roorkee City

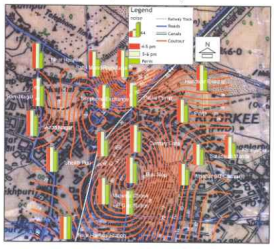
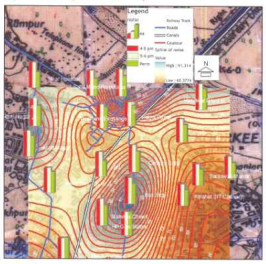


Fig. 7 : Noise Map for Roorkee City




Noise contours are computed in GIS by interpolating noise levels computed on a raster of points. An accurate and complete picture of the noise situation in the surroundings of a noise source can only be obtained if the density of points is sufficiently high. The density should be high close to the noise source and near noise obstructing objects, while parallel to the source and further away from the source less calculation points are needed and desired. This results in a decreased computation time. Obviously, the needed density of calculation points also depends on the desired level of detail of the study, which is dictated by the purpose of the study.

The developed model was then validated through the comparative analysis of calculated and observed noise level. To avoid the Mathematical complexities, MS EXCEL worksheet system has been used to formulate the Model. This model can be used to predict noise levels (Leq) due to road traffic. In this model, the user can get the noise level by putting the inputs i.e. characteristics of site, category wise traffic volume, speed of vehicles. Various adjustments i.e. flow adjustment, distance adjustment and grade adjustment are made to basic noise levels to arrive at final noise levels. The value of final LAeq is determined from the following equation:

$$LA_{eq} = L_0 + \Sigma L_i$$

Where, LAeq is continuous steady noise level on A-weighted scale, L0 is basic noise level for a stream of vehicle and Li is adjustments for each vehicle category. Final equivalent noise level has been predicted on the basis of reference energy mean emission levels of different category of vehicles. According to Indian traffic condition, the vehicles are divided into seven categories in this model and consequently seven equations have been incorporated into model. Table 6 shows the reference energy mean emission levels equations.



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One hour equivalent sound level from a given class of vehicle is calculated by summing up the various adjustments to the energy mean emission level

$$L_{eq}\ H = L_0 + \Delta traffic + \Delta distance + \Delta shielding + \Delta grade + \Delta segment + \Delta barrier$$

Where, L0 is the contribution of a given vehicle class, Δtraffic is traffic flow adjustment for a given class of vehicles, Δdistance is distance adjustment for a given class of vehicles, Δshielding is shielding adjustment for a given class of vehicles, Δgrade is grade adjustment for a given class of vehicles, Δsegment is segment adjustment for a given class of vehicles and Δbarrier is barrier adjustment for a given class of vehicles.

Table 5 : The Reference Energy Means Emission Levels Equations

| | |
|---|---|
| Car/Jeep/Van | Y=32.372*logS+15.891 |
| Minibus | Y=31.212*logS+23.26 |
| Truck | Y=43.248*logS+6.597 |
| Bus | Y=41.378*logS+8.873 |
| Motorcycle | Y=35.871*logS+8.979 |
| Auto | Y=0.2202*logS+61.51 |
| Tractor trailer | Y=6.411*logS+73.065 |

Table 6 : Comparative Analysis of Observed and Calculated Noise Level at Different Locations

| S.No. | LOCATION | EQUATIONS | A | B1 | B2 | B3 | B4 | B5 | R2 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Azad Nagar | Y = A + B1 * X | 22.910 | 0.686 | | | | | 0.777 |
| 2 | Ram nagar | | -2.511 | 1.003 | | | | | 0.771 |
| 3 | Near Hospital | | 25.815 | 0.660 | | | | | 0.897 |
| 4 | Near Railway Station | | 2.327 | 0.950 | | | | | 0.949 |
| 5 | PWD | | -7.920 | 1.079 | | | | | 0.907 |
| 6 | Telephone Exchange | | 36.460 | 0.495 | | | | | 0.875 |
| 7 | Khanjarpur | Y = A + B1*X + B2*X2 + B3*X3 | 1746.520 | -70.103 | 0.979 | 0.004 | | | 0.718 |
| 8 | HP Gas Station | | 1.113 | -44283.022 | 586.927 | -2.592 | | | 0.827 |
| 9 | Saraswati Mandir | | -21466.426 | 956.971 | -14.177 | 0.069 | | | 0.798 |
| 10 | Sabji Mandi | | 16151.243 | -564.367 | 6.592 | 0.025 | | | 0.940 |
| 11 | Rajputna | | 288834.703 | -13894.702 | 222.789 | -1.190 | | | 0.855 |
| 12 | Sheikh Puri | | 34942.170 | -1349.495 | 17.397 | -0.074 | | | 0.819 |
| 13 | IRI | | 33801.334 | 1275.322 | 16.057 | -0.067 | | | 0.616 |
| 14 | Petrol Pump (Canal) | Y = A + B1*X + B2*X2 + B3*X3 + B4*X4 | 6.676 | -352532.427 | 6978.748 | -61.389 | 0.202 | | 0.873 |
| 15 | Malviya Chowk | | 900654.814 | -43209.617 | 777.192 | -6.210 | 0.018 | | 0.644 |
| 16 | Bus Stop | | 520188.459 | -24453.543 | 430.993 | -3.375 | 0.009 | | 0.603 |
| 17 | Century Gate | Y = A + B1*X + B2*X2 + B3*X3 + B4*X4 +05*X5 | -100554.336 | 4791.838 | -85.507 | 0.677 | -0.002 | | 0.770 |
| 18 | Haridwar Road | | -184487.972 | 9289.184 | -175.210 | 1.467 | -0.004 | | 0.728 |
| 19 | Alipahar | | -1.131 | 8.163 | -2.356 | 34010.927 | -245.395 | 0.708 | 0.996 |

The comparative study between observed and calculated equivalent noise levels(FHWA model) at different monitoring location shows linear or polynomial regression analysis between observed and calculated value which shows better coefficient of correlation.

## 6. STUDY APPLICATION

Noise map developed clearly shows high noise levels at different locations of Roorkee which could have a negative impact on city. Therefore certain measures should be implemented to abate noise nuisance.

**Table 7 : Attenuations Possible Due to Different Noise Abatements**

| Abatement measures | Reduction In Noise Levels (dBA) |
|---|---|
| Noise Barrier | 15 |
| Vegetation | 5 |
| Restricting Honking | 10 |

In Fig. 8 location requiring noise abatement measures in Roorkee city are shown. Noise barrier near traffic highway can considerably reduce the noise levels which has been depicted in noise map of Roorkee city (Fig. 9) and contours generated after noise abatement measures (Fig 10). The most fertile areas for roadway noise mitigation are in urban planning decisions, roadway design, noise barrier design, speed control, surface pavement selection and truck restrictions. Speed control is effective since the lowest sound emissions arise from vehicles moving smoothly at 30 to 60 kilometers per hour. Above that range, sound emissions double with each five miles per hour of speed. At the lowest speeds, braking and (engine) acceleration noise dominates. Selection of surface pavement can make a difference of a factor of two in sound levels, for the speed regime above 30 kilometers per hour. Quieter pavements are porous with a negative surface texture and use medium to small aggregates; the loudest pavements have a transversely grooved surface, and/or a positive surface texture and use larger aggregates. Surface friction and roadway safety are important considerations as well for pavement decisions. Noise barriers can be applicable for existing or planned surface transportation projects. They are probably the single most effective weapon in retrofitting

**Fig. 8 : Location Requiring Noise Abatement Measures in Roorkee City**






an existing roadway, and commonly can reduce adjacent land use sound levels by up to 15 decibels.

Noise levels measured at different landuses in Roorkee were compared with the existing noise levels of the selected locations with the standards and other permissible limits. Results of analysis and noise map developed in GIS were used to classify the study area into different groups of noise levels and land uses. From the analysis of data presented in the preceding sections, the following conclusions can be drawn.

- Noise levels observed for the residential areas such as Rajputana, PWD and Near Railway Station is quite high to the ambient national standard of 55 dBA.
- In heavy commercial areas of Roorkee Township the Leq level is quite high as compared to the ambient national standard of 65 dBA requiring specific abatement measures.
- Sensible noise climate has been observed in areas like near hospital, exceeding the standard of that for silence zone due to its proximity to national highway.
- Higher noise levels in Alpahar, IIT Roorkee and Irrigation

**Fig. 9 : Contour Map After Reduction in Noise if Noise Abatement Measures Taken**

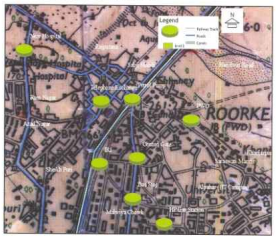
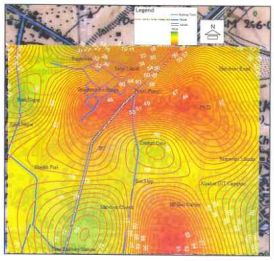



**Fig. 10 : Noise Map after Noise Reduction Measures**



Research Institute exist because of their location adjacent to busy road with high volume of thorough traffic.

- Careful attention of local authority is warranted in land use planning in Roorkee for restricting any kind of development that may produce negative impact.
- Noise contours developed in GIS has been utilized to show different land uses of Roorkee city in figures in which Roorkee is primarily divided into three different zones.
- Noise map developed highlights requirement of abatement measures near highways and intersections to reduce traffic noise.
- Comparative study between observed and calculated equivalent noise levels(FHWA model) at different monitoring location shows linear or polynomial regression analysis between observed and calculated value which shows better coefficient of correlation and this validates the FHWA model in Roorkee city.

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