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Static Modelling and Noise Pollution: A GIS Approach to Environmental Modelling

Arushi Rana

School of Earth Sciences, Banasthali Vidyapith, Niwai, Tonk 304 022, Rajasthan, India

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ABSTRACT

Noise is the unwanted by product of anthropogenic activities. Mining deteriorates several aspects of environment including the land, soil, air, water. Noise pollution is one the core reasons of ill health of mine labors and resident population. The current paper focuses on the Kota stone industries in Ramganjmandi, Rajasthan. Day time monitoring is executed for the region. Maximum noise level is 120.4 dB(A) and minimum value is 50(A). The mean value is 85.93 dB(A). Interpolation is used to predict the noise levels in the unsampled sites. Inverse distance weightage method is used to for interpolation using ArcMap software. Voronoi mapping of the region is also used to demarcate the region into convex polygons depicting the impact.

Key words: *Noise, Pollution, Interpolation, Voronoi, Mining*

Introduction

Noise pollution is an invisible danger. It cannot be seen, but it is present nonetheless, both on land and under the sea. Noise pollution is any undesirable or disturbing sound that affects the health and well-being of humans and other organisms. For several decades, noise regulations have centered on human disorders but recently, public policies in biodiversity conservation have started to pay more consideration to noise pollution. In 1996, for the first time, the European Commission's Green Paper on Future Noise Control Policy dealt with noise pollution from the point of view of environmental protection. Today in Europe, quiet areas are recommended to guarantee the tranquillity of fauna (Sordello *et al.*, 2019). Noise is regarded as a pollutant under the Air Prevention and Control of Pollution Act, 1981. It is defined as an unwanted sound, undesirable by-product of human activities. It has adverse effects on human beings and their environment including land structures and domestic animals. Sound is a mechanical vibration of a gaseous, liquid or solid elastic medium through which energy is transferred away from the source by progressive sound waves. The number of compressions and rarefactions of air molecules in a unit time is described as its frequency. It is expressed in Hertz (Hz). Human ear can detect sound with frequencies ranging between 16Hz to 29KHz. Below 16Hz is called Infrasound and above 20KHz is known as Ultrasound. Intensity of sound is known as Power (W) transmitted Per unit area(A) normal to its direction of propagation and can be expressed as

$$I = \frac{W}{A}, \text{watts}/\text{m}^2$$

Decibel is the unit of noise and $1/10^{th}$ of a bel. It is the logarithmic ratio of two powers/intensities/ pressure. The threshold of hearing is 0dB and the threshold of Pain is 130dB. A widely used scale to measure sound pressure levels is the weighting scale, "A-weighting." It correlates with the subjective response of auditory system and is expressed as decibels in A-Scale (dBA).

In opencast mines, noise is generated in almost all the mining operations, becoming thereby an integral part of the mining environment. Prolonged exposure to high levels of noise (>90dBA) proves harmful (Tripathy, 1994). Conventional mining and mineral processing activities that contribute to noise pollution include overburden removal, drilling and blasting, excavating, crushing, loading and unloading, vehicular traffic, and the use of generators. Depending on the mobility and nature sound can be from fixed sources, mobile sources, impulsive sources, continuous sources, intermittent sources, impact sources (Jain, 2016). Noise has both auditory and non-auditory effects. The auditory impacts include temporary hearing loss and permanent hearing loss. Besides this noise can also lead to Physiological changes such as Cardiovascular problems, ulcers, communication interference, irritation and anxiety, behavioral changes, nervous system related changes, hormonal changes, sleep interference, loss of efficiency. The air pollution control act 1981 has prescribed different noise levels. The maximum working period prescribed as 8 Hr at 90dB(A). The limit is progressively reduced by 50 % for every 3dB(A) increase in noise level. Thus, the maximum working period comes only 2 min at 114dB(A). The central pollution control Board noise standards are based on international standard organization. Noise level standard for mining areas is decided as per MOEF notifications 25th September, 2000. It should be 75dB(A) during daytime and 70dB(A) during nighttime and the monitoring shall be once in a fortnight (Maiti, 2011).

A study on Sao Paulo Brazil for develop land use regression model depicts the negative impacts of noise pollution in low- and middle-income countries research. The scarce data exposure and noise maps hampers the depiction of impacts of noise pollution.

Noise is an ignorant pollutant, but it is a growing health concern. In 65.2% of the sampled sites in Katmandu city, the noise level was beyond the acceptable limit of WHO and National Sound Quality Standard of Nepal (Chauhan, 2021).

In a study of stone crushing industry of Eastern Dwarka basin, it is found the level of the noise declines as one moves away from the crushing center. The level of noise prevails up to 500 to 600m away from it. The maximum noise level recorded is 112.41dB(A) which may cause deafness. Noise vulnerable areas constructed based on eight noise level addressing and noise effect indicating parameters using fuzzy logic revealed that about 10.46–27.98% areas fall under very high to high noise vulnerable zones. Approximately 209 to 3160 people live in the selected clusters and population density is 48 persons/km^2 to 163 persons/km^2 in the very high-noise susceptible zone. Stone mining and crushing industries has been causing pollution in several forms, and this effect may be transferred among the people who are living at the adjoining part (Pal, 2021).

Presently, noise pollution is considered as one of the key problems of urban communities that has several hazardous effects on the urban environment and cause several problems which needs to be adhered to. Exposure to noise alters moods and can be causative of anxiety and panic disorders.it can push the preexisting anger issues (World Health Organisation, 1999, 2001). There are five significant developments in the 2018 version of WHO policy regarding noise pollution which includes, stronger evidence of cardiovascular and metabolic effects of environmental noise; inclusion of new noise sources, namely wind turbine noise and leisure noise, in ad-

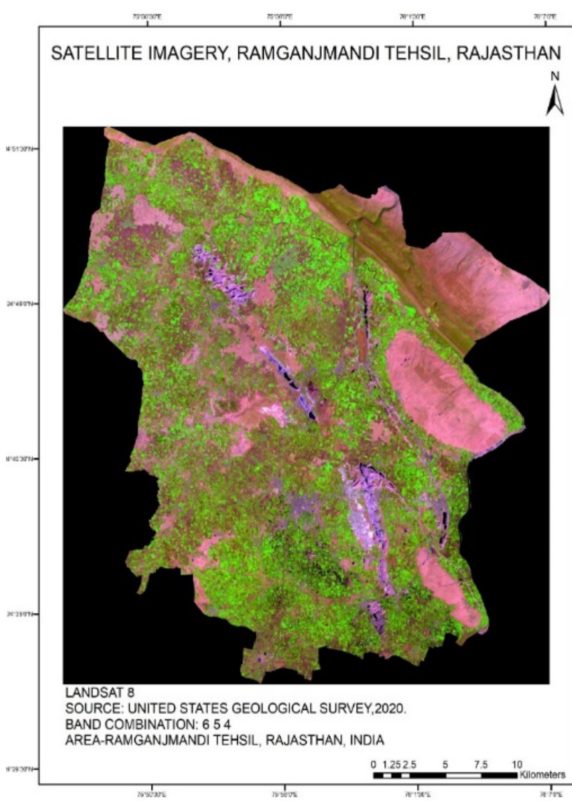

Fig. 1. A satellite portrayal of Ramganjmandi Tehsil

dition to noise from transportation (aircraft, rail and road traffic); use of a standardized approach to assess the evidence; the systematic reviews of evidence define the relationship between noise exposure and risk of health outcome; and use of long-term average noise exposure indicators to better predict adverse health outcomes, compared to short-term noise exposure measures (World Health Organisation, 2018).

Ramganjmandi is a tehsil (Block) of the district of Kota in the state of Rajasthan, in which lies the Ramganjmandi city. It is known as a stone city and coriander city. It is 73 kms away towards south of Kota on the Delhi-Mumbai broad gauze railway line. The latitudinal extension is 24° 08´00´´N to 24° 11´ 10´´N and the longitudinal extension is 75° 13´ 04´´ E to 76° 01´ 57´´ E. The area possesses semi-arid conditions. The average maximum temperature is 48 °C and the average minimum temperature is 9 °C. The average annual rainfall is 85.18 cm and average humidity is 42%. The winds move from west to east in summers and north-east to southwest in winters. The soil is black with deposits of limestone.

Ramganjmandi once famous for coriander cultivation is now famous for mines, extraction, mine mafias, poor air quality, water unfit for drinking, loss of agricultural land, deforestation, massive solid waste disposal. Although the region is herein demarcated based on administrative boundary, but the economic activity of Kota stone mining mostly lies in the tehsil except for few areas of Jhalawar district. Either hills are covered with Kota stone scrap or mounds of scraps have been created. This not only diminishes the aesthetic value of the place but also create environmental degradation (Rana and Sharma, 2020).

Materials and Methods

Primary survey for noise level is conducted using SL-1352 Professional sound level meter is used to measure dBA, A weighted Decibels, which is general noise level. Slow mode is used. The meter is kept 1 to 1.5 meter away from the sound source. The Microphone is kept at Ear level. The reading is then noted along with the GPS location at the source. Interpolation is executed using Arc GIS software using spatial analyst tool predicting the values of the unsampled sites. The output value for a cell using inverse distance weighting (IDW) is limited to the range of the values used to interpolate. Because IDW is a weighted distance average, the average cannot be greater than the highest or less than the lowest input. Therefore, it cannot create ridges or valleys if these extremes have not already been sampled (Philip and Watson, 1982).

Results and Discussion

Noise Levels in Ramganjmandi Tehsil

Day time monitoring is executed for the region. Maximum noise level is 120.4 dB and minimum value is 50. The mean value is 85.93 dB. The standard deviation for the noise level is 20.01. The median value is 80.6. The low noise level is found around the Mukundara national park in the north of tehsil. The mining region shows high sound level as high as 120.4 in Kumbhkot region.

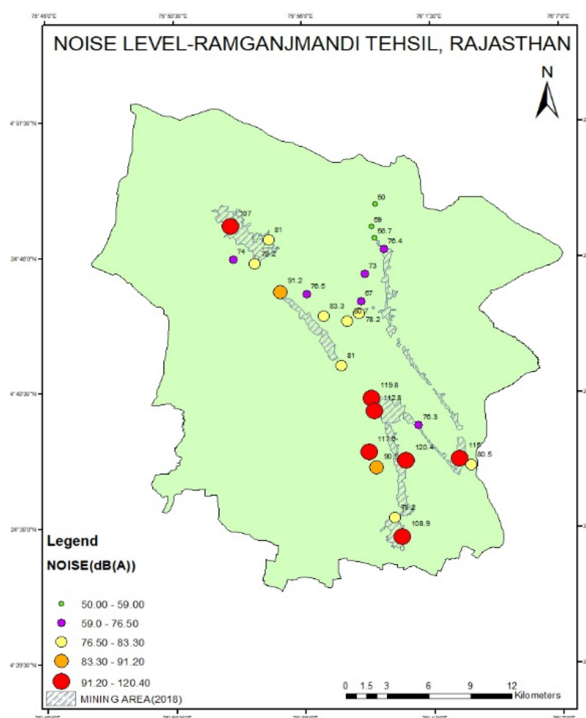

Fig. 2. Noise levels in Ramganjmandi Tehsil

The sampled sites are compared to few standards. As per WHO guidelines, 96% sampled sites are unfit. As per the MOEF, 2000 guidelines80.76% are unfit. As per WHO and ILO guidelines according to area categories 92.85% are unfit. As per OSHA/ILO guidelines 61.53% are unfit.

Voronoi Mapping of Noise Levels

Besides the scatter plot, Voronoi map of the region is

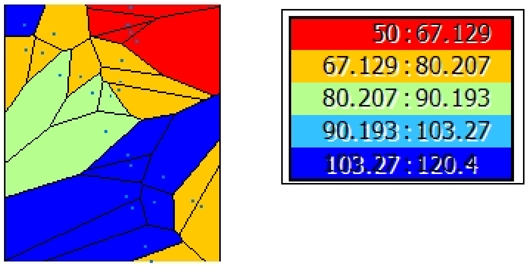

Fig. 3. Voronoi Mapping of the Noise Levels

generated. Mode value is used to create the Voronoi map of the region, since mean values do not fit for the region because of extreme values. It is the partitioning of the plain to n points into convex polygons such that each polygon contains exactly one generating point and every point in a given polygon is closer to its generating point than to any other. A Voronoi diagram is sometimes also known as a Dirichlet tessellation. The cells are called Dirichlet regions, Thiessen polytopes, or Voronoi polygons. One can see high values towards south east and north west section, which lies in the mining belt. Low values are found in the northern territory which is in fact a silence zone.

Interpolated Noise levels

The sampled sites are interpolated using inverse distance weightage method focusing more over the mining belt. Higher values are seen near Kumbhkot, Julmi, Suket and Chechat. The active mining belts are to the soouth of the tehsil depicting high noise levels which reduces as we move towards the northern part of the tehsil. Higher values of 110 to 121dB are seen into developing 3 core regions to the south and one towards the north western part of the territory of the tehsil.

Conclusion

The spatial modelling of the Noise pollution data

Table 1. Noise levels and comparison to standards

Sample no	Noise level db(a)	Type	WHO (community guidelines)	MOEF, 2000	WHO/ILO	OSHA/ISO
1	76.4	Mining	Unfit	Unfit	Category N/A	Fit
2	78.2	Residential	Unfit	Unfit	Unfit	Category N/A
3	81	Mining	Unfit	Unfit	Category N/A	Fit
4	90.5	Mining	Unfit	Unfit	Category N/A	Unfit
5	112.8	Mining	Unfit	Unfit	Category N/A	Unfit
6	115	Mining	Unfit	Unfit	Category N/A	Unfit
7	108.9	Mining	Unfit	Unfit	Category N/A	Unfit
8	50	Sensitive	Fit	Fit	Fit	Category N/A
9	83.3	Residential	Unfit	Unfit	Unfit	Category N/A
10	80.7	Residential	Unfit	Unfit	Unfit	Category N/A
11	74	Residential	Unfit	Fit	Unfit	Category N/A
12	107	Mining	Unfit	Unfit	Category N/A	Unfit
13	79.2	Residential	Unfit	Unfit	Unfit	Category N/A
14	76.5	Mining	Unfit	Unfit	Category N/A	Fit
15	73	Residential	Unfit	Fit	Unfit	Category N/A
16	117.6	Mining	Unfit	Unfit	Category N/A	Unfit
17	120.4	Residential	Unfit	Unfit	Unfit	Category N/A
18	80.5	Residential	Unfit	Unfit	Unfit	Category N/A
19	119.8	Mining	Unfit	Unfit	Unfit	Unfit
20	76.3	Mining	Unfit	Unfit	Category N/A	Fit
21	78.2	Residential	Unfit	Unfit	Unfit	Category N/A
22	56.7	Residential	Unfit	Unfit	Unfit	Category N/A
23	59	Residential	Unfit	Fit	Unfit	Category N/A
24	67	Residential	Unfit	Fit	Unfit	Category N/A
25	81	Mining	Unfit	Unfit	Category N/A	Fit
26	91.2	Mining	Unfit	Unfit	Category N/A	Unfit
Percentage of sampled sites unfit			96% unfit	80.76% unfit	92.85% unfit	61.53% unfit

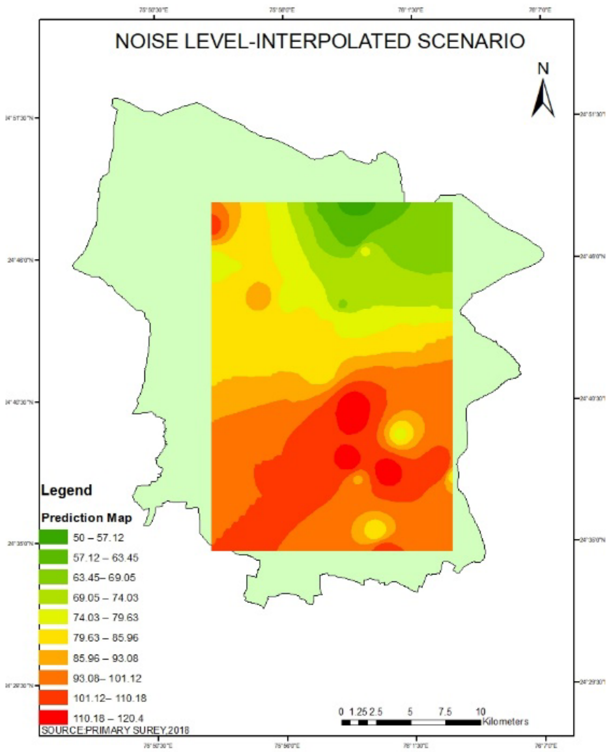

Fig. 4. Interpolated Noise Levels

depicts High Noise levels in the southern part of the tehsil which includes the Kumbhkot, Suket Julmi regions. The Voronoi map of the region confirms the same. Mining in the region is imposing high noise levels. The samples sites are compared to several standards, according to which 96% sampled sites are unfit as per WHO standards. As per the MOEF, 2000 guidelines 80.76% are unfit. As per WHO and ILO guidelines according to area categories 92.85% are unfit. As per OSHA/ILO guidelines 61.53% are unfit.

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Conflict of Interest: None

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