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A Review on Noise Pollution Monitoring, Mapping, Modelling, and Health Impacts

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ABSTRACT. Most people are not aware that noise from road traffic is the principal cause of annoyance to exposed people. In relation to this, the review aims at providing an overview of research carried out on noise pollution monitoring, mapping, modelling, and health impacts in recent years in different countries. The electronic databases were searched to select the studies related to noise monitoring, mapping, modelling, and health impacts on humans. A total of 91 most relevant studies were reviewed in this article. A comparison of different instruments available for noise monitoring was done. Studies related to monitoring and mapping reveal that most of the locations have higher noise levels in the environment, breaching the noise limits. Only a few articles enumerated health impacts and zone-specific monitoring. Many researchers have conducted a questionnaire-based study related to health to identify the impact of noise. Noise models for many developing countries are not available, so their development and modification are still in progress. Proper zone-specific studies and noise maps will help the town planner with better land use planning. Continuous monitoring stations for noise in crowded cities shall be implemented to mitigate noise pollution. Based on the review, it is concluded that long-term research on noise pollution is very much needed worldwide.

Keywords: noise levels, monitoring, mapping, sound level meter, noise models

1. Introduction

The levels of noise in the local environment fluctuate from time to time as a result of both natural and artificial sources. Each nation on earth is currently struggling with issues brought on by various forms of pollution. The increased noise levels in cities are one of the emerging global problems that are being experienced all over the world (Wu et al., 2019). The amount of environmental noise pollution has a significant financial impact on the cost of real estate in both residential and commercial regions (Prascevic et al., 2014). Because of the extremely rapid rate at which it may be eliminated, noise pollution is one of the concerns in many developing countries that receive the least amount of attention. In a recent article by the World Health Organization (WHO) at least one hundred thousand individuals in the European Union are negatively impacted by traffic noise and at most one and a half million healthy years of life are lost annually as a direct result of this (WHO, 2018). WHO has also declared noise pollution as the third most hazardous pollution after water and air pollution (Basu et al., 2021). According to Murgel (2007), the growing usage of machinery during the Industrial Revolution in the XVIII and XIX centuries has been the primary contributor to the worsening of noise pollution. This trend began throughout those ages.

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The rate at which pollution is rising in major urban centres is concerning due to the rapid pace of urbanisation and the accompanying rise in the number of automobiles in those areas. The most significant sources of worry are associated with noise as well as air pollution. Air pollution and ambient noise frequently coexist since they are produced by the same sources, such as traffic (Yu et al., 2023). Likewise, seventy percent of the overall noise in our surroundings is caused by vehicles (Calixto et al., 2003; Omidvari and Nouri, 2009). Manufacturing processes, vehicular traffic, air and railway traffic, construction noise and home noise are the primary contributors to overall noise levels (Tashakor and Chamani, 2021; Parker and Spennemann, 2022). However, various factors can influence the impact of traffic noise, including vehicle type and status, road infrastructure performance, automotive size distribution and physiological state, and weather conditions. (Thakre et al., 2020). The primary factor that contributes to an increment in noise levels is due to an increasing number of vehicles that are driven on roads (Licitra et al., 2015; Wolniewicz and Zagubień, 2015). Speed of vehicles contributes to high levels of noise on road and the addition of 2 to 5 decibels (dB) of noise levels is done by honking of vehicles (Vijay et al., 2015). Noise level not only disrupts the natural surroundings that surround the construction site (often referred to as environmental noise) but it also harms the workers who are doing their jobs at the construction site (i.e., occupational noise) (Engin et al., 2019; Ning et al., 2019). Psychological issues, hearing disorders, elevated blood pressure, and irregular heartbeats are just some of the non-auditory and auditory effects that can be brought on by exposure to industrial and traffic noise (Halonen et al., 2016; Akintunde et al., 2022). Other effects include cardiovascular disease, sleeplessness, irritability, stress, decreased job productivity, and trouble understanding conversation (Dzhambov et al., 2017; Potgieter et al., 2018; Terry et al., 2021). Children are also at high risk due to the higher noise levels (Stansfeld and Clark, 2015).

Mapping of noise is a significant technique for urban planning as it may be used for assessing, managing, and controlling the level of environmental noise (Bocher et al., 2019). To produce comprehensive noise projections for a specific area, a map that gives an overall evaluation of noise exposure in that area as a result of several noise sources must be created. Planned noise mapping is the display of noise data including but not limited to: noise indicators such as Lden and Lnight when a threshold is crossed, predicted number of homes exposed to noise levels and noise-exposed persons. The presentation of noise data is the primary focus of the noise mapping whereas the evaluation of noise exposure is the primary focus of the strategic noise mapping (Borelli et al., 2014). In Europe and other nations, many studies were conducted to create noise maps of cities (Vogiatzis and Remy, 2019). In recent years, a large number of scientific models have been developed with a focus on this aspect of the problem and the exclusive use of empirical formulations for source emission and acoustic waves. Models have been built, tested and implemented into regular use in their respective nations. Additionally, they have been integrated with geographic information system (GIS) interfaces to generate noise maps. In addition to the source characterisation, more sophisticated numerical approaches such as the wave equation and the continuity equation are utilised to resolve the effects of sound transmission. These models as a result make use of computers with high processing speeds and trained operators in order to accomplish their ultimate goals. Therefore, it is of the utmost importance to conduct research in a scientific manner and evaluate each of these models side-by-side in order to ascertain the general applicability of each of them and to identify the strategy that is the most suitable for the modelling of traffic noise (Garg and Maji, 2014).

In the past two decades, a huge proportion of research has been conducted by researchers to look into the impact of roadway noise exposure on healthful living, sleep disruption, deterioration, high blood pressure, hypertension, and cardiac issues. The bulk of studies examining the harmful effects of road noise on social networks reported using social survey questionnaires. The fundamental objective of this review is to evaluate and manage the information on the monitoring of noise pollution, mapping of noise levels, impact on human studies, and modelling of noise pollution that has been carried out all over the world in the most recent decades.

2. Noise Pollution Monitoring and Mapping

When a sound is "subaudible", it means that it is under the limit of human listening and therefore underneath the range at which it can be heard (Kamp and Den, 2018). In today's world, there are many types of pollution, but noise pollution is particularly prevalent. Since it differs from person to person, geographical location to geographical space, degree of growth to rapid industrialization noise pollution can be considered a geographic problem. It also differs depending on the causes of the problem and the level of impact which is mostly determined by the amount of exposure and how frequently it occurs. It is a spatiotemporal phenomenon of significant importance since noise levels can vary greatly across different geographical locations. Measuring the noise from vehicles is not an easy task because of the variety of automobiles that are on the roadways, as well as the quality of the roads and the amount of crowding. In addition to these factors, the horns of automobiles are another significant contributor to the increased levels of noise in the surrounding environment (ElAarbaoui et al., 2017). The amount of noise is typically expressed as an equivalent continuous sound level (L_{eq}) and is referred to using the decibel (dB) measurement system. L_{eq}, which stands for "equivalent continuous sound level" is a valuable tool for describing varying noises as a single number (Kumar et al., 2017).

Figure 1. Sound level meter class I.

Several distinct kinds of sound level metres (SLM) are utilised for noise level monitoring. Figure 1 shows the SLM which is used for carrying out the noise survey. These sound level metres are elevated to a height of 1.5 metres from the ground and set on tripod stands (CPCB, 2015). At the moment most common varieties of SLM are known as Class/Type I and II, respectively. Type I SLM provide a higher level of accuracy and is typically utilised for the measurement of noise caused by things like air and traffic, whereas Type II SLM is typically utilised for the measurement of indoor noise like in offices and classrooms. The SLM that is used to carry out the monitoring needs to comply with the standards established by IEC 61672-1. The results of a comparison of Type I and Type II SLM as well as the major performance characteristics of each may be found in Table 1.

According to Akhtar et al. (2016) noise map is a graphical depiction of the noise levels in a given area at a given time. In terms of compatibility, they are incredibly useful in land-use distinction, auditory urban planning and the evaluation of any activity that impacts the environment (Mishra et al., 2021). Gaining an understanding of the factors that contribute to the

Table 1. A Contrast of the Primary Characteristics of Class I and Class II SLM

Specification[a,b]	Class I	Class II
Standards	IEC 61672-1	IEC 61672-1
Precision and cost	Most precise and most expensive	Less accurate and less expensive
Area of use	Environment noise (noise from railway, traffic, and aircraft), building acoustics, sound power or engineering measurements	Environments, such as offices, classrooms, or general industrial facilities
Noise levels range	30 to 130 dB	30 to 130 dB
Range of frequency	16 Hz to16 kHz	20 Hz to 8 kHz
Linear operating range	60 dB dynamics between the lowest measured dB and the highest	60 dB dynamics between the lowest measured dB and the highest
Temperature range for operating	−10 to 50 °C	0 to 40 °C
Smallest and largest operation range	30/140	30/140
Frequency weighting	A, C, and Z weightings of frequency	A, C, and Z weightings of frequency
Calibration	Must be adjusted to the level produced by the sound calibrator	Must be adjusted to the level produced by the sound calibrator
Tolerance limits at 1 kHz	+/− 1.1 dB	+/− 1.4 dB
Tolerance limits at 16 kHz	+2.5 and −4.5 dB	+5.5 and −∞ dB

Note: Sources: [a] https://www.cirrusresearch.co.uk/blog/2011/10/whats-the-difference-between-a-class-1-and-class-2-sound-level-meter/ (retrieved on 02/08/2022); [b] https://svantek.com/academy/types-of-sound-level-meters/ (retrieved on 02/08/2022).

varying levels of noise can give a solid foundation for noise mapping and the discovery of long-term solutions to the issue. The noise map prepared in one of the studies for observed noise levels is shown in Figure 2. The GIS tool and several interpolation methods are utilised in the creation of noise maps. Interpolation was performed with inverse distance weighting (IDW) in the majority of the research projects that were carried out.

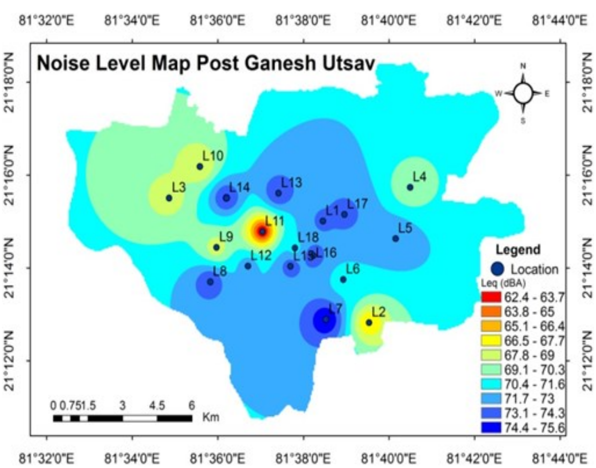

Figure 2. Prepared noise map in one of the studies (Kumar et al. 2023a).

2.1. Previous International Study on Noise Monitoring and Mapping

Noise levels between 75.2 ~ 75.35 dB were observed in a study carried out in China, Iraq, Egypt, and Brazil (Li et al., 2002; Zannin et al., 2002; Ghatass, 2009). These levels were also greater than the recommended benchmark. The noise investigation that was conducted in Poland and Columbia demonstrates that the equivalent level of noise remains within the prescribed value (Sondakh et al., 2014). The process of industrialization goes hand in hand with the progress made by developing countries. Residents of Jalgaon city participated in a community survey that Ingle and Pachpande (2005) carried out to get information on traffic noise levels. Both of the target groups showed signs of having a slight hearing disorder in audiometric examination (uncovered and exposed population). It was determined that the population's prolonged exposure to increased noise levels harmed their ability to hear, and this was the conclusion that was reached.

Das et al. (2019) examined the principal noise producers, noise mapping, and diurnal noise cycle in a heavily congested and heavily populated area. According to the findings of this study, the most annoying type of noise annoyance was caused by traffic noise (58.65%), followed by construction activities (21.15%). Noise measurement analysis of traffic flow under an interrupted flow condition was carried out by Parbat et al. (2011) in the intermediate Yavatmal city based in the Vidarbha region of the Maharashtra state, India. Within the scope of this investigation, modelling of artificial neural networks was carried out, and as a direct result, noise prediction was executed. Masum et al. (2021) studied noise level and pollution's spatiotemporal fluctuation indicators of Chattogram City Corporation (CCC) in Bangladesh. According to the findings of the study noise levels were excessive on average and much over the guidelines established by the DoE, Bangladesh and the WHO for human habitation. The details of few past studies on noise monitoring and mapping have been shown in Table 2.

2.2. Merits and Demerits of Noise Monitoring and Mapping Technique

The main benefit of utilising a SLM is that it offers precise and unbiased readings of noise level in a given location. SLM measures sound levels quantitatively. It can measure levels across a wide frequency and amplitude range, making it suitable for assessing many types of noise pollution. It offers real time noise level monitoring, which can be useful in identifying noise sources and applying control measures. Current SLM are simple

Table 2. Past Studies on Noise Monitoring and Mapping

Study Area and Country	Zone of Study	Intervals	Number of Stations	Mapping Tool	References	Remarks
University of Jos/Nigeria	S and R	M, A, and E	17	GIS/IDW	Akintunde et al. (2022)	Noise levels of 53 to 135 dB were observed, which is 35 dB more than the acceptable limit.
Osun/Nigeria	I	M, A, and E	10	GIS/IDW	Ayanlade and Oyegbade (2016)	Noise and PM1mostly came from the industry due to the wind movement.
Copacabana/ Brazil	R and C	M, A, and E	14	CADNA-A	Pinto and Mardones (2009)	Noise mapping proves to be an effective method for combating noise pollution, and simulations are powerful tools for use in urban planning.
Foshan/China	R, C, I, and S	D	50	GIS/IDW	Yang et al. (2020)	Noise levels were greater at non-peak times, perhaps because of the higher speed and greater volume of traffic.
Dublin/Ireland	R, C, I, and S	D	12	--	Basu et al. (2021)	Sound levels were found to be lower during the lockdown. 80% of stations had higher noise for 60% of time.
Mumbai/India	R, C, I, and S	D	153	GIS/IDW	Kalawapudi et al. (2020)	Areas designated as silence zones have suffered the most from noise.
Erzurum/ Turkey	Road Traffic	M	12	--	Gökdag (2012)	Aggressive driving in low ratios by a medium-weight vehicle was the major factor for noise in inner-city traffic.
Nagpur/India	R, C, and I	M and E	700	GIS/TIN	Laxmi et al. (2019)	Bicycles are convenient for navigating and due to small size and lack of engine noise it is excellent tool in unapproachable areas.
Delhi/India	I, C, R, and S	M, A, and E	10	GIS/-	Mishra et al. (2021)	The noise level was found to be proportional to the volume of traffic.
Peshawar/ Pakistan	C, R, and S	D	20	GIS/-	Munir et al. (2021)	Noise levels in 70% of the area rise from winter to spring. Wind speed, humidity and temperature played a vital role in causing seasonal variations.
Raipur/India	S	M, A, and E	15	GIS/IDW	Kumar et al. (2023b)	Sources of noise in the premises were traffic, honking of trains followed by students themselves.

Note: I - Industrial Zone, S - Silence Zone, R - Residential Zone, C - Commercial Zone, M - Morning, A - Afternoon, E - Evening, and D - 24 hours.

to operate and do not necessitate substantial training or expertise. Because SLM are portable, they can be used in a number of contexts, including outdoor spaces and industrial areas. SLM offer standardised as well as recognised readings by governing bodies.

Mapping noise levels could help identify locations with adequate sound levels, distribution of noise levels, hotspots that require immediate attention and land uses that might need to be reassigned. The key drawback of noise monitoring and mapping is expensive, as many organizations won't have many funds to buy software and instruments. Also At any given time, it can only cover a restricted area. As a result, obtaining a comprehensive picture of noise pollution across a vast geographic area may be difficult. Noise pollution monitoring and mapping equipment is not always precise. This can result in mistakes in data collection, affecting the development of noise control measures. It may not capture all sources of noise pollution. For example, it may be unable to identify noise pollution from particular types of cars or interior activities.

3. Studies on the Consequences of Noise Exposure on Humans

Long-term effects of traffic noise on mortality were discovered in a study by Barceló et al. (2016), while Camusso and Pronello (2016) investigated the links between vehicular traffic and annoyance for different types of metropolitan sites. Two comprehensive reviews one by Baliatsas et al. (2016) and the other by Recio et al. (2016) examined the impacts of low-frequency noise on health, specifically infrasound in the general population and the effects of road traffic noise on cardiovascular, pulmonary, and metabolic health. The findings of the study indicate that researchers should devote more time to studying the effects of ambient noise, especially on those who reside close to major sources. Münzel et al. (2018) conducted a comprehensive review that centred on the mechanics and epidemiology of noise-induced cardiovascular diseases. This review offers new insight into the mechanisms that are behind noise-induced vascular damage. It was noted that two fascinating review studies had been published; one of these articles dealt with noise exposure and diabetes (Sakhvidi et al., 2018) and the other piece focused on chronic noise exposure and obesity (An et al., 2018; Sun et al., 2018) conducted research and investigated the influence of interaction between the ability to focus attention and visual elements on the annoyance caused by road traffic noise. The fact that these components interact with one another gives additional evidence to back up the idea that audiovisual attention plays a role in the development of noise irritation. A comprehensive analysis of road traffic noise and its effects on

Table 3. Past Studies on the Impact of Noise on Human

Study Area	Target Population/ Respondents	Questionnaire	Remarks	Reference
Delhi/India	520	Yes	Respondents mostly experienced disruption, headaches, and discomfort. 70% said they viewed road traffic to be the most irritating form of noise pollution.	Kumar (2019)
Kuwait	1,400	Yes	Residents in heavily travelled areas report much greater levels of stress and noise sensitivity.	Al-Mutairi et al. (2011)
Southern Sweden	24,238 adults (18 ~ 80 years)	Yes	Correlation between noise levels of road traffic and self-reported hypertension in middle-aged people was reported.	Bodin et al. (2009)
Juiz de Fora /Brazil	140 (128 students and 12 staff)	Yes	55% of the people said that they were upset by noise and of those people, only 50 % tried to remedy the problem while they were studying or working.	de Souza et al. (2020)
Faisalabad/ Pakistan	4 age groups (< 20, < 40, < 60, and < 80)	Yes	People suffered from headache (94%), sleeplessness (76%), hypertension (74%), physiological stress (74%), high blood pressure (64%), dizziness (60%), and loss of hearing (56%) due to noise.	Farooqi et al. (2020)
Jhang, Chiniot/ Pakistan	200	Yes	Respondents in Jhang and Chiniot suffered annoyance (53 and 51%), depression (45 and 47%), dizziness (61 and 65%), headache (67 and 64%), hypertension (71 and 56%), hearing loss (53 and 56%), physiological stress (65 and 65%), sleeplessness (81 and 84%), and tinnitus (70 and 62%).	Farooqi et al. (2021)
Srinagar/India	565 Quiet area (N = 102) Noisy area (N = 463)	Yes	84% reported an inconvenience by traffic noise. Quality of sleep was rated as poor by nearly 62.3%.	Gilani and Mir (2021)
Mainz-Bingen/ Germany	4,826	Yes	Aircraft noise annoyed 60% of people during the day and 30% during sleep.	Hahad et al. (2021)
Neipu, Pingtung County/ Taiwan	Staff (N = 283) Patients and visitors (N = 290)	Yes	Sources found were nurses shouting (58.3%), rolling of trolley wheels (58.0%), visitor's voices (70.0%), and children playing (83.0%). Professionals with more than 5 years of experience said sound level impacted their work emotions.	Juang et al. (2010)

Table 4. Some Country's Decibel-Based Noise Standards (dB)

Zone	US (EPA)	WHO and EC	Japan (MOE)	Australia (EPA VIC)	India (CPCB)
Industrial Zone (Day/Night)	70/60	65	60/50	65/55	75/70
Commercial Zone (Day/Night)	60/50	55	60/50	55/45	65/55
Residential Zone (Day/Night)	55/45	55/45	50/40	45/35	55/45
Silent Zone (Day/Night)	45/35	45/35	45/35	45/35	50/40

Note: Source: Chauhan et al. (2010).

human health in India was published by Banerjee (2013). The study covered all of the significant studies that were conducted from 1991 to 2012. According to the findings of his study, there are not a lot of studies accessible that deal with the effects of traffic noise on people's health in India.

Agarwal and Swami (2009) found a link between the level of discomfort caused by traffic noise in Jaipur and the various noise indices that were measured. To determine how annoying noise is, a quantitative point scale known as the mean disturbance score (MDS) was developed. There was a correlation found between the mean noise index (L_{eq}, L_{10}, L_{max}, and TNI), the percentage of people who were highly agitated and MDS. The issues of noise pollution and its influence in terms of irritation in urban settings were investigated by Agarwal and Swami (2011) in the city of Jaipur. Within the scope of these investigations, the prediction of noise annoyance caused by motor road traffic was carried out. The results of a questionnaire study showed that 52.6% of respondents were suffering from regular annoyance, 46.6% from hypertension, and 48.6% from sleep disruptions due to automotive noise. Along with these studies, a few studies on the impact of noise on human have also been shown in Table 3.

3.1. Research with a Particular Focus on the Role of Noise during Celebrations in India

During the Prime festival, Kumar et al. (2023a) measured the noise levels of the city of Raipur's commercial, residential, and silence zones to determine how disruptive the noise was. The recorded noise levels were significantly greater than the noise limit that was prescribed. During the Ganesh festival in the city of Kolhapur in the state of Maharashtra, Saler and Vibhute (2011) conducted research on the effects of noise pollution. The noise levels were measured at different intervals during the day and night and found that most of the levels exceeded the allowed limit, causing individuals who were exposed to it to become extremely irritated. Singh and Joshi (2010) investigated the levels of noise pollution in various areas of Meerut city on the evening of Deepawali festival. They found that the average level of noise in the commercial area was 83 dB, while the average level of noise in the residential area was 85 dB. As a result of increased awareness of the environment, the decibel levels in 2009 were much lower than those recorded in 2007 and 2008. The levels of noise that were present during Deepawali in Balasore were measured by Goswami et al. (2013) on two separate occasions, in the years 2010 and 2011. During both of those years, both the Lmax and the L_{eq} values were greater than 110 dB. The noise levels that were measured during the Dussehra festival in the town of Balasore were measured by Swain et al. (2013). Over five days, the noise descriptors L_{10}, L_{50}, L_{90}, L_{eq}, NPL, and NC were measured and analysed. Every one of the measured noise levels exceeded the maximum allowable decibel level established by the Central Pollution Control Board in India. The standards of a few countries in the world are shown in Table 4.

3.2. Merits and Demerits of Questionnaire Technique

Questionnaire surveys are less expensive and faster to administer than other research approaches such as laboratory studies or field observations. It can quickly reach a vast and diverse population, enabling for a more comprehensive understanding of noise health implications. To ensure uniformity in data collection and processing, questionnaire surveys can be standardised. This technique can collect both quantitative and qualitative data, offering a more comprehensive picture of the effects of noise on health.

We all know that this technique relies on self-reported information, which can be biased and inaccurate. Some aspects of noise health impacts, such as physiological reactions, may not be captured by surveys because they require more specific equipment or knowledge to measure. Individual differences in noise sensitivity and tolerance may be missed by surveys. Response rates may be poor, resulting in potential sample biases and a less representative population under research.

4. Studies with a Focus on Modelling of Noise in Developing Country

Alam et al. (2020) monitored the levels of noise caused by road traffic throughout the day and at night. He also evaluated the RLS-90 noise prediction model by using the monitored data. In addition to that, t-test validation was carried out on the RLS90 model. The ranges of 0.06 to 1.86 standard deviations were observed for the difference between the noise level that was measured and the noise level that was predicted. For several sites in Delhi, Garg et al. (2015) showed how artificial neural networks may be used to forecast the L_{Aeq} and the sound level that exceeds the L_{10} owing to traffic noise. The results of the study demonstrated that the model is capable of making reliable forecasts of the hourly levels of traffic noise. Sharma et al. (2014) created a model of traffic noise that may be used in metropolitan areas with a variety of different traffic situations. The noise model for Indian traffic circumstances demonstrated significantly improved results compared to an earlier established noise model. Gulliver et al. (2015) studied Traffic Noise Exposure (TRANEX) model in the cities of Leicester and Norwich in the United Kingdom. High correlation (Norwich: r = 0.85, p = 0.000; Leicester: r = 0.95, p = 0.000) between the modelled and measured $L_{Aeq,1h}$ with average model errors of 3.1 dB were observed. Dai et al. (2014) carried out a study on inland waterway traffic noise prediction model based on the US FHWA model. Changes were made to the definitions of many of the input variables. The noise levels that were anticipated and those that were measured had a difference of 0.15 ± 1.75 dB on average. Givargis and Mahmoodi (2008) study describes the approach that was utilised in the conversion of CORTN model into algorithms that were capable of calculating the hourly A-weighted $L_{Aeq,1h}$ for the roads in Tehran. In the first strategy, the model was calibrated by performing a nonlinear regression parameter estimation using fifty percent of the samples. In the second method, the calibration of the model was performed based on the results of thirty measurements gathered from two different roadways. After that performance test was carried out and the result indicated that both approaches produce satisfactory results. Kuldeep et al. (2021) performed an experimental investigation by selecting sixteen significant locations all around the city to investigate the level of noise pollution caused by traffic in Kota city. Comparing projected and actual data for traffic sound levels, the Fagotti-Poggi model was determined to be the best accurate model for forecasting levels of noise at sample sites. Sheng et al. (2015) investigated the precision of the CRTN model in forecasting traffic noise levels in an Asian city where motorcyclists make up more than half of the vehicles on the road. The results revealed that the CRTN model performed adequately in forecasting roadside traffic noise levels, with an R^2 of 0.832 and a mean difference of 0.52 dB between observed and expected values. Ranpise et al. (2021) worked on assessing the levels of noise at important arterial roads in the city of Surat and developed a noise forecasting model by utilising an artificial neural network. Shokouhian et al. (2021) utilised Traffic Noise Model (TNM) to compute the noise caused by highway traffic and evaluate the effectiveness of noise reduction measures. A detailed comparison of different models has been presented in Table 5.

5. Merits and Demerits of Model Technique

Noise modelling can provide a precise and realistic depiction of noise pollution in a given location, assisting in the identification and assessment of potential health implications. It can aid in forecasting the impacts of noise reduction measures, allowing for better educated noise management and mitigation decisions. This technique can be used to explore the geographical and temporal variability of noise pollution, which can aid in the identification of high-exposure areas and the development of specific solutions. Noise modelling can be used to simulate various scenarios and analyse the possible performance for other noise management approaches, which can be less expensive than carrying out solutions directly in the field.

On the other hand, noise modelling necessitates a large amount of data, including information on the sources of noise

Table 5. Comparison of Noise Model Concerning a Wide Range of Variables

Name of Model	Expression	Explanations	Country	Reference
Basic Statistical Model	$L_{50} = 68 + 8.5Log(Q) - 20Log(d)$ $L_{eq} = 55.5 + 10.2Log(Q) + 0.3P - 19.3Log(d)$ $L_{eq} = L_{50} + 0.018(L_{10} - L_{90})^2$ $L_{10} = 61 + 8.4Log(Q) + 0.15P - 11.5Log(d)$ $L_{50} = 44.8 + 10.8Log(Q) + 0.12P - 9.6Log(d)$ $L_{90} = 39.1 + 10.5Log(Q) + 0.06P - 9.3Log(d)$	Q: traffic volume (v/hr); d: distance from observation point to lane center; P: percentage of heavy vehicles.	United States Australia England	Bolt (1952) Burgess (1977) Griffiths and Langdon (1968)
	$L_{eq} = 10Log[Q(1 + 10P/100)]$		Brazil	Calixto et al. (2003)
Federal Highway Administration Traffic Noise (FHWA)	$L_{Aeq,1h} = E_{Li} + A_{traffic(i)} + A_d + A_s$	$A_{traffic(i)}$: traffic flow adjustment; A_d: distance between the roadway and the receiver and the roadway length adjustment; A_s: shielding and ground effect adjustment.	United State of America	ROSAP (1998)
Calculation of Road Traffic Noise (CoRTN)	$L_{10(1h)} = 42.2 + 10Log(q)$ $L_{10(18h)} = 29.1 + 10Log(Q)$	q: hourly traffic flow (vehicles/hour); Q: 18-h flow (vehicles/hour).	United Kingdom	Givargis and Mahmoodi (2008)
Richtlinien für den Lärmschutz an Straben (RLS 90)	$L_{m,E} = 37.3 + 10Log[Q(1 + 0.082p)]$	L_m: mean A-weighted level; Q: traffic flow (according to road type); p: percent heavies for road (above 2.8t).	Germany	Quartieri et al. (2009)
HARMONOISE	$L_{WR}(f) = a_R(f) + b_R(f)\ Log(v/vref)$ $L_{WP}(f) = a_P(f) + b_P(f)\ Log(v\text{-}vref/vref)$	$vref$: 70 km/hr; coefficients a_R, b_R, a_P, and b_P are presented in 1/3 octave bands in a frequency range of 25 to 10 kHz.	The European Member States	Defrance et al. (2007); Jonasson (2007)

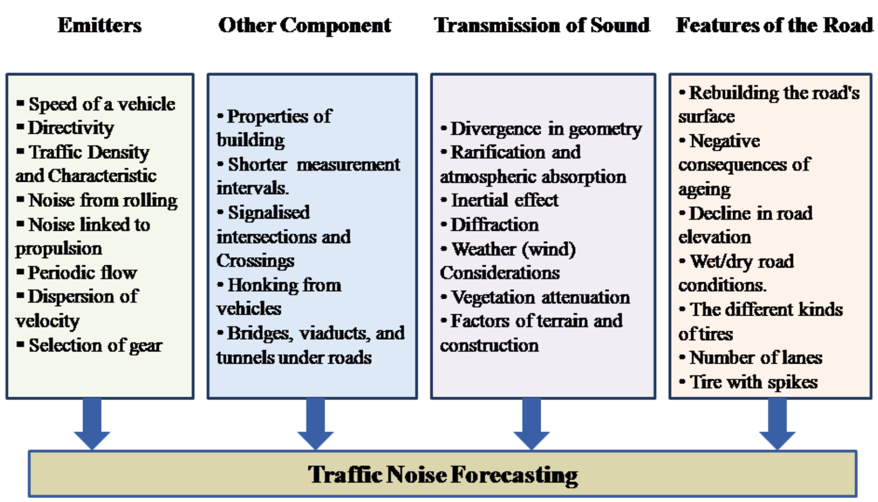

Figure 3. Factors that influence the prediction of traffic noise.

pollution, sound wave propagation, and the topography and built environment of the research area. It is complicated and requires specialised knowledge and skill in acoustics and modelling methodologies, making it inaccessible to non-experts. Because it is based on assumptions and simplifications that may not entirely represent the actual conditions, noise modelling may not fully capture the diversity and complexity of real-world noise pollution. Uncertainties in the input data might alter the quality and reliability of the model predictions, affecting the results of noise modelling.

The studies above describe the monitoring and mapping of noise pollution along with its harmful effect on people. Also, different noise model comparison has been carried out along with studies related to noise level forecasting in detail. Factors that influence the forecasting of noise traffic are shown in Figure 3. From the past studies, it is revealed that not many studies have been done in many of the developing countries related to the harmful impacts of noise on humans. Studies related to the monitoring of noise pollution have used SLM and GIS tools for generating the noise map. In most of the studies, a noise map has been prepared by utilization of the interpolation method (IDW) in GIS. Thus, IDW is one of the most suitable methods of interpolation for preparing the noise map. Apart from this CADNA-A is also one of the tools for noise mapping however it is not common in most studies. Zone-wise noise monitoring and mapping is required for better results and source identification. In most of the studies, different zones have been identified for monitoring noise and based on that noise maps have been generated. The different zones as per the governing bodies are silence, residential, commercial, and industrial. Different standard limits have been given by the governing bodies worldwide. The comparison of standard limits of the different countries has been carried out to understand the prescribed limits of noise in the world.

Monitoring of noise is carried by SLM of different types and comparing the specification of instruments it is found that SLM type I is more suitable than type II for performing the study as the tolerance limit of type I is better. However, depending on the area to be monitored suitable instruments can be selected for the study. From the model study, different input parameters and other factors have been discussed in detail. Based on the observations developing countries still need to develop their noise prediction model as per their road conditions. Some models will not give proper output as each model is developed according to the country scenario. Talking India still does not have its noise model for the prediction of noise; work is still going on for developing a noise model according to the Indian scenario. However, few studies have been conducted with existing models and modification has been made to them by some researchers. The focus should be made on developing models that require less time, easy installation, and operation so that they can be used by untrained personnel also.

Impacts on humans have been studied by researchers by performing the questionnaire survey. From the studies, it has been found that most of the studies have reported people feeling discomfort from the high levels of noise. Headache, sleep disturbance, hearing issue, low performance and rise in blood pressure has been reported by many studies. Thus, it can be said that noise has harmful effects on noise and many more deep studies are required for a better understanding and mitigation of noise pollution.

6. Current Views and Future Development in Noise Pollution

Academic perspectives on the research status and future development trend of noise pollution indicate that the issue is becoming increasingly significant and urgent attention is required. Exposure to noise pollution has been demonstrated in studies to have a number of harmful effects on human health, and as the population grows and urbanisation rises, noise pollution is becoming a serious public health concern.

Further study on the health effects of noise pollution, as well as effective preventative and mitigation techniques, is required. Recent research efforts have concentrated on developing new methods for measuring and mapping noise pollution, as well as assessing the efficacy of various noise reduction strategies. There is also significant interest in the use of technology for noise pollution monitoring and analysis, such as artificial intelligence and machine learning.

In order to handle the issue's complexity, future growth trends are likely to entail increasing collaboration between multiple disciplines, such as acoustics, environmental science, and public health. There will also be a greater emphasis on community involvement and participatory techniques, which can assist to raise awareness of the issue and include local people in the development of effective noise reduction strategies. Ultimately, there is a need for more noise pollution study and action in order to build a better and more sustainable living environment for everybody.

7. Conclusions

The paper discusses monitoring, mapping, model study and the impact on human health by noise pollution in various countries. From the study, it is quite obvious that noise monitoring and mapping are essential for different cities in developing countries. The generated noise maps will help in identifying the hotspot and provide a platform for lawmakers to mitigation of noise pollution in the environment. More future investigation on the impact of noise on humans is required in developing countries. For better land use planning by local bodies modelling based studies must be carried out so that it will help them. Each upcoming study must come out with source identification and mitigating approaches to noise pollution in the environment. However, in developing countries, it is not possible to completely avoid noise pollution, but preventive measures will reduce it to some extent to bring the noise levels nearer to the standards limits. Proper following of noise rules shall be monitored so that noise pollution is under control however in developing countries it is not followed to its full extent due to rapid growth in construction, traffic, and industrialization. 24 × 7 noise monitoring stations shall be made in populated cities countrywide so that proper monitoring will be done. This will help in identifying the hotspot and help in proper land use planning for minimizing the harmful effects on the exposed population.

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