Noise Mapp. 2022; 9:48–66 DE GRUYTER

Review Article

Ramesh B. Ranpise* and Bhaven N. Tandel

Urban road traffic noise monitoring, mapping, modelling, and mitigation: A thematic review

https://doi.org/10.1515/noise-2022-0004
Received Oct 10, 2021; accepted Mar 26, 2022

Abstract: This article analyses the most recent studies on urban traffic noise. About 67 relevant articles on urban road traffic noise and its mitigation strategies were preferred for a critical review. Only 5.97% of items describe how to monitor and record the noise measurement for urban roads, while 7.46% of articles enumerated urban traffic noise pollution exposure. 29.85% of articles proposed a model to evaluate noise reduction effects and predict the noise level. Also, many articles reported noise map generation and its analysis. 56.71% of articles described the noise mitigation strategies in detail, concerning noise control by green vegetation, land use planning, low noise tire and pavement material, noise reduction through façade shielding. Noise pollution standards are being breached in all areas. There is a need for the proper implementation of rules and regulations. Therefore, noise mitigation strategies such as designing noise barriers and other noise control materials are needed. Finally, it is summarized that economic and low-cost optimized noise pollution mitigation strategies like ingeniously made noise barriers, vegetation and landscaping are need of the hour for urban areas of developing countries.

Keywords: Noise mitigation strategies, noise modelling, noise mapping, noise exposure, noise barrier

1 Background of study

Noise pollution is an increasing environmental apprehension [1]. Noise from urban road traffic produces more annoyance to the people than any other noise source. Moreover, this menace to health and quality of life has been growing over the past years for several reasons.

***Corresponding Author: Ramesh B. Ranpise:** Department of Civil Engineering, Sardar Vallabhbhai National Institute of Technology, Surat, India; Email: ranpiseramesh6588@gmail.com
Bhaven N. Tandel: Department of Civil Engineering, Sardar Vallabhbhai National Institute of Technology, Surat, India

An aggressive rise in vehicles on roads has expanded the traffic noise level [2, 4, 5]. The principal noise mitigation or reduction area is transportation noise control, structural plan, urban arranging through zoning code, and industrial noise control. Traffic noise may affect on sleep quality and mental health [6]. The increase in urban areas' population has caused to enlarge in traffic leading to an exponential growth in noise pollution [7]. Nowadays, traffic noise in an urban region is the principal factor of noise. It is the dominant source of noise in living and the working environment [8]. It severely impacts roadside residents, leading to a significant decrease in their quality of life [9]. Noise has expanded quickly in all regions, particularly urban zones in the last thirty years. Noise mitigation strategies involve noise reduction at the source of transportation noise and the receiver [10].

In this study, the author used systematic and definite methods [11, 12] to identify, select, and critically appraise relevant research and collected data for analysis. It also sums up the future perspectives of urban noise and its mitigation strategies. The paper reviewed emphasises the importance of abatement policies and mitigation strategies in controlling noise pollution due to urban road traffic. Urban road traffic noise and its consequent influence over traffic and façade may be considered a "big issue" in scientific research. Traffic noise becomes severe at residential dwellings, and shopping complexes are built along the mainstream of traffic to fulfil people's housing demands [13]. Several typical noise control measures have been suggested to implement road traffic noise problems in the past few decades. This review article's main objective is to present the research carried during the past years on noise mitigation strategies adopted worldwide. It also gives a detailed summary of acoustic research related to noise mapping, modelling, and exposure.

Since past years, urban traffic noise studies have generally been engrossed in noise monitoring, mapping, modelling, and health effect [14–19]. This review article clearly shows that urban traffic noise is the main element [16] that annoy the respondent. Proper and effective transportation planning is essential to make traffic flow uncongested and restrain urban sprawl [20, 21], which reduces noise exposure.

This review concerns urban road traffic noise and its mitigation strategies. Strategies such as traffic management, limiting speed [20, 22] in residential areas, forbidding horn use by law [5], driver awareness program [23], rules for pedestrians, and road layout.

In developing countries, traffic noise pollution is becoming a severe problem because of poor planning [24] of the public transportation system in metropolitan areas. Traffic noise is 55% of the total environmental noise [25, 26]. In highly populated cities, traffic is the major parameter that contributes more noise [27]. Continual exposure to traffic noise caused severe health effects [2]. From the papers reviewed, it can be inferred that the minimum road traffic noise level observed was 55 dBA and the maximum was 89 dBA [26, 28–30].

The present paper attempts to conduct metadata and content analysis related to urban road traffic noise. The following sections discuss the methodology adopted to carry out the literature review. The third section deal with descriptive analysis of selected papers. The fourth section carries out the detailed categorical analysis followed by the results and conclusion sections.

2 Research methodology

In this study, the author reviewed Sixty-seven articles (64 journal and three conference papers) that were reviewed scrupulously to give out the status of traffic noise and its mitigation strategies worldwide. Methods narrated by Omlin [31], Goswami [32], and the WHO guideline [12] were used to represent this review of the literature.

2.1 Material Collection

The allied articles were explored by string search, database search (Taylor and Francis, Elsevier, Springer, ASCE, Science Direct, Google Scholar, etc.), "conference proceeding", and "authors' library search". String searches incorporated keywords like urban road traffic, urban noise, noise control, noise mitigation strategies, exposure effect of noise, noise in schools, colleges, hospitals, and roadside dwellers, festival noise, urban traffic noise modelling, noise abatement, noise control materials, noise impact assessment, noise control through vegetation, noise mapping, noise control rules and standards.

2.2 Material refinement

Every pertinent and recognized article and research paper were studied and referred for detailed extraction and kept in the form of a database having details of data collection, publication details, author name, study location, year, methodology for monitoring and evaluating the noise exposure and noise mitigation strategy applied, sample size, major conclusion. The standards adopted to determine the papers' quality included statistical tools and methods, detailed descriptions, well-defined mitigation strategies, and a well-defined noise monitoring system.

2.3 Descriptive analysis

The explanation gives the results and information related to methods used, location, type of work, and research. The selected sixty-seven articles on urban traffic noise and its mitigation strategies are scrutinized as per the published articles into categories like journal, year of publication, author, publisher and author's geographical location etc.

For data investigation, qualitative synthesis is adopted in this study, as there is so much heterogeneity in studies which prohibit considerable conclusions. This study concentrated on examining noise from urban traffic and its mitigation strategies at both the receiver's end and the noise source itself [33, 34]. Table 1 gives the details of noise pollution studies in various aspects; it also provides articles primarily based on noise mitigation strategies. It may be helpful to researchers working in the noise pollution control area because the papers reviewed provide the studies include various mitigation options such as low noise road surface [35, 36], quieter engine [37–39], low noise tires [20, 37, 40], electric vehicles [20, 41, 42], building sound insulation [38, 43, 44], land use planning, building design (door/windows) [45, 46], sonic crystals [47], and design and efficiency of different types of barrier [48–50].

2.4 Categorical analysis

In this step, urban traffic noise is categorized based on an interrelated theme such as noise monitoring, noise modelling and mapping, noise exposure and health effect, noise mitigation strategies. Traffic noise modelling is a major research issue in an urban context. Several types of research were carried out in the past, but a comprehensive literature paper seems unreported. The existing literature review on urban traffic noise categorized with different aspects is tabulated in Table 1.

Table 1: List of studies on urban road traffic noise categorised with different aspect

Sr. No.	Author	Study Location	Type of study	Year of publication	Noise measurement	Measurement of impact	Statistical method / Tool used	Modeling used	Sample size / Measurement points	Mitigation strategy applied	Type of article
					THEME – Noise monitoring						
1	G. Zambon	Italy	Review	2018	Review	Review	Review	Review	Review	NA	Review auricle
2	N. Garg	India	Research work	2017	Yes	Yes	Yes	Yes	35	Noise monitoring network	Research article
3	Vijaya Laxmi	India	Research work	2019	Yes	Yes	Yes	Yes	700	Monitoring by cycle	Research article
4	Rahman Farooqi	Pakistan	Research work	2017	Yes	Yes	Yes	Yes	86 Sites	Evaluation and analysis	Research article
					THEME – Noise modeling and mapping						
5	Debnath	India	Research work	2018	Yes	Yes	Yes	Yes	Yes	Prediction model	Research article
6	Kumar	India	Mathematical Model	2011	Yes	Yes	Yes	Yes	Yes	Mathematical model	Research article
7	O Gundogdu	Turkey	Research work	2016	Yes	Yes	Yes	Yes	04*	Prediction model	Research article
8	H N Rajkumara	India	Research work	2009	Yes	Yes	Yes	Yes	16	Prediction model	Research article
9	Manoj Jha	Maryland	Research work	2009	Yes	Yes	Yes	Yes	NA	GIS-based model	Research article
10	D. Banerjee	India	Research work	2009	Yes	Yes	Yes	Yes	35	Appraisal and mapping of traffic noise	Research article
11	Khaled Hamad	Sharjah UAE	Research work	2017	Yes	Yes	Yes	Yes	3	Modeling using ANN	Research article
12	Edgar Eduardo	Canada	Research work	2016	Yes	Yes	Yes	Yes	32	Traffic noise model for road intersections	Research article
13	Dipesh Sonaviya	India	Research work	2019	Yes	Yes	Yes	NA	5	2-D Noise mapping	Research article
14	Arvind Kumar Shukla	India	Research work	2009	Yes	Yes	Yes	Yes	10	Noise prediction model	Research article
15	Ye Chuan Deng	China	Research work	2016	Yes	Yes	Yes	NA	NA	3-D Noise mapping	Research article
16	S. Rahmani	Iran	Research work	2011	Yes	Yes	Yes	Yes	3	Modeling using G.A.	Research article
17	Hyung Suk Jang	Republic of Korea	Lab analysis	2015	Yes	Yes	Yes	Yes	NA	Scale model to assess the noise reduction	Research article
18	Meehan	China	Experimental Study	2019	Yes	Yes	Yes	Yes	NA	Modeling and mitigation	Research article

Table 1: ...continued

Sr. No.	Author	Study Location	Type of study	Year of publication	Noise measurement	Measurement of impact	Statistical method / Tool used	Modeling used	Sample size / Measurement points	Mitigation strategy applied	Type of article
19	Hui Di	China	Research work	2018	Yes	Yes	Yes	Yes	4	Acoustic estimation and Modelling	Research article
20	Wenzu Zhang	Singapore	Research work	2020	Yes	No	Machine learning	Yes	NA	Framework in noise prediction	Research article
21	Yan LIU	China	Lab analysis	2010	Yes	Yes	Yes	Yes	NA	Urban road traffic sound	Research article
22	Ranpise R. B.	India	Field survey	2020	Yes	Yes	Yes	Yes	3	MLR modeling of traffic noise	Book chapter
23	N. Garg *et al.*	India	Research work	2015	Yes	Yes	Yes	Yes	8	Comparison of ANN and analytical model in traffic noise	Research article
24	Simon de Lisle	Australia	Research work	2016	Yes	Yes	Yes	Yes	2	Comparison of Road Traffic Noise Prediction Models: TNM, CoRTN, ASJ RTN, NMPB,	Research article
					THEME – Noise exposure and health effects						
25	Kim	Indiana polis	Research work	2015	Yes	Yes	Yes	Yes	Yes	Noise impact analysis	Research article
26	D. Montes Gonzalez	Spain	Research work	2018	Yes	Yes	Yes	Yes	3	Acoustic screening effect on the building facade	Research article
27	Xiaoying Wen	China	Field Survey	2019	Yes	Yes	Yes	Yes	06	Impact of traffic noise on school	Research article
28	Tandel B. N.	India	Research work	2013	Yes	Yes	Yes	NA	3	Road traffic noise exposure	Research article
29	Yadav M	India	Research work	2019	Yes	Yes	Yes	NA	12	Traffic noise on Roadside shopkeepers	Research article
					THEME – Noise mitigation strategies						
30	Timothy Van Renterghem	Belgium	Research work	2015	Yes	Field survey	Yes	No	02	Landscaping	Research article
31	Ogren	Sweden	Data study	2018	Yes	Yes	Yes	Yes	20 years scenario	Low noise tire-pavement	Research article
32	Schiff	Sweden	Research work	2010	Yes	Yes	Yes	Yes	Canyon	Canyon rooftop absorption	Research article
33	Zannin	Brazil	Research work	2006	Yes	Yes	Yes	Yes	Highway stretch	Noise barrier	Research article
34	Carlos Leiva	Spain	Experimental study	2019	Yes	Yes	Yes	Yes	Yes	Noise barrier	Research article

Table 1: ...continued

Sr. No.	Author	Study Location	Type of study	Year of publication	Noise measurement	Measurement of impact	Statistical method / Tool used	Modeling used	Sample size / Measurement points	Mitigation strategy applied	Type of article
35	Louis F. Cohn	U.S.	Data study	1984	Yes	Yes	Yes	Yes	NA	Noise barrier	Research article
36	K. Kumar	India	Field survey	2014	Yes	Field survey	Yes	Yes	Highway stretch	Noise barrier	Research article
37	L. H. Huang	Taiwan	Relationship Study	1992	Yes	Yes	Yes	Yes	NA	Noise barrier	Research article
38	Christian H Kasess	Austria	Lab analysis	2016	Yes	Yes	Yes	Yes	NA	The efficiency of the noise barrier	Research article
39	Tomas Gil-Lopez	Spain	Experimental Study	2017	Yes	Yes	Yes	Yes	NA	Noise barrier from tree pruning waste	Research article
40	Rosewell A. Haris	U.S.	Research work	1985	Yes	Yes	Yes	Yes	2	Vegetation as a barrier	Research article
41	Lai Fern Ow	Singapore	Research work	2017	Yes	Yes	Yes	Yes	3	Noise reduction through vegetation	Technical note
42	Vinita Pathak	India	Research work	2008	Yes	Yes	Yes	Yes	11	Abatement through Vegetation	Research article
43	Chang Liu	Netherland	Research work	2018	Yes	Yes	Yes	Yes	2	Effect of water content on noise attenuation	Research article
44	M. Hornikx	Sweden	Research work	2009	Yes	Observer	Yes	Yes	02	Grass surface, façade Absorption	Research article
45	C. Mendonca	Portugal	Research work	2013	Yes	Yes	Yes	Yes	89 Participant	Vehicle and pavement	Research article
46	Miomir Miljkovic	Germany	Research work	2014	Yes	Yes	Yes	Yes	4	Pavement texture study	Research article
47	Daniel E. Karkle	Manhattan K.S.	Research work	2011	Yes	Yes	Yes	Yes	10	Rumble strip noise	Research article
48	Deok-SoonAn	Korea	Research work	2017	Yes	Yes	Yes	Yes	4	Rumble strip noise	Research article
49	Bo Tian	China	Research work	2014	Yes	Yes	Yes	Yes	5	Reduction of tire pavement noise	Research article
50	E. Freitas	Portugal	Research work	2012	Yes	Listener	Yes	No	96	Pavement type	Research article
51	Dae Seung Chi	Korea	Research work	2008	Yes	Yes	Yes	Yes	6	Noise from various road surface types	Research article
52	Gaetano Licitra	Italy	Research work	2014	Yes	Yes	Yes	Yes	3	CPX for noise mitigation	Research article
53	Parviz A Koushki	India	Research work	2002	Yes	Yes	Yes	Yes	12	Exposure to the noise inside transit buses	Research article

Table 1: ...continued

Sr. No.	Author	Study Location	Type of study	Year of publication	Noise measurement	Measurement of impact	Statistical method / Tool used	Modeling used	Sample size / Measurement points	Mitigation strategy applied	Type of article
54	Felix Laib	Germany	Research work	2019	Yes	Yes	Yes	Yes	3 Type of buses	Noise reduction using electric buses	Conference paper case Study
55	R. K. Mishra	India	Field Survey	2010	Yes	Yes	Yes	Yes	13	Noise analysis at BRTS	Research article
56	Sneha Singh	India	Experimental Study	2018	Yes	Yes	Yes	Yes	2 sets of expt. (8 Sound)	HVAC noise control in the car	Research article
57	Willian Bowlby	Tenn	Field Survey	1985	Yes	Yes	Yes	Yes	6	Highway noise control	Research article
58	Pizzo	Italy	Practical application	2019	Review paper	Review paper	Review paper	Review paper	N.A.	Sonic crystals	Review paper
59	Naveen Garg	India	Socio acoustic survey	2012	Yes	Yes	Yes	Yes	NA	Noise abatement	Research article
60	Francesco D Alessandro	Italy	Field /Lab analysis	2019	Yes	Yes	Yes	Yes	19	Noise abatement plan	Research article
61	Kurt Heutschi	Switzerland	Data study	2016	Yes	Yes	Yes	Yes	NA	Options for reducing noise	Research article
62	Yeung	China	Laboratory test	2014	Yes	In situ test	No	No	21*	Plenum type acoustic window	Conference paper
63	G. H. Pandya	India	Field survey	2001	Yes	Descriptor	No	Yes	4*	Acoustic design and planning	Research article
64	Mirshekarloo	Singapore	Practical application	2018	Yes	In situ test	Yes	Yes	NA	Window design	Research article
65	Henrik Andersson	France	Data study	2018	Yes	Yes	Yes	Yes	NA	Estimation of road noise charges	Research article
66	M. Hornikx	Sweden	Research work	2009	Yes	Yes	Yes	Yes	Shielded canyons	Noise abatement schemes	Research article
67	J. E. Wesler	Review Study	Journal article	1973	N.A.	Review article	N.A.	N.A.	N.A.	Noise control rules	Review article

*mean= measurement points/centres
**mean= sample size

2.5 Cluster analysis

In this study VOS viewer software has been utilized to explore the literature data and cluster analysis of examined papers, to extract keywords and create connections. This study represents the temporal and geographical connections between the various studies [51].

3 Urban road traffic noise monitoring, mapping, modelling, and mitigation

3.1 Studies with prominence on urban road traffic noise monitoring

Urban traffic noise [52] is the primary origin of the noise, and it depends on the volume of vehicles [53] as well as on other factors like road conditions [54], traffic clearance [55, 56], and condition of vehicles [53, 57], speed of the vehicle [58–62] and the individuals living close to the side of the road (parkway) are for the most part uncovered. Noise monitoring helps identify the problems [13], get the idea about propagation, and study the exposure effect.

Zambon *et al.* [15] reviewed the noise prediction model of urban traffic noise in Italy. They provided a precise description of traffic noise, mainly measuring road noise from observation points adequately spread over the interest zone. They prescribed the criteria for the selection of noise monitoring points.

N. Garg *et al.* [18] established the noise monitoring network over the seven big cities in India. They depicted the typical yearly L_{dn} (6:00-22.00) and L_n (22.00-06.00) values. They stated that the drawn-out noise checking gives that including noise levels have vaguely extended since late years in 35 regions under assessment in that 14 areas are in the commercial zone, 7 in private, 5 in industrial and nine silent zones. The investigation is uncommonly helpful in discovering the significance of yearly typical noise levels, preparing for noise control action plans, and specifying changed enveloping noise standards in the Indian situation.

Vijaya Laxmi *et al.* [63] had carried out noise pollution monitoring by using a sound level meter set up on the bicycle with mould attached. According to the author, the cycle is a silent method for transport, and in this manner, they used it for noise level observing more than 700 areas in India's Nagpur city. They have taken noise levels at every site for 5 min throughout the peak times of heavy traffic in the first part of the day. Indices of noise such as L_{90}, L_{10}, L_{max}, and L_{min} and Leq were observed for information and noise level examination. Corresponding noise levels were moved into the GIS software, and spatial examination devices were utilized to make key noise maps. Finally, values show that noise levels throughout the city exceed Indian noise standards.

Rahman Farooqi *et al.* [64] evaluated and analyzed noise in a traffic area in various parts of Faisalabad city in Pakistan. They found the surge and the struggle between the majority identifying with the transit regulations all over the place, their infringement, and their delayed repercussions. They evaluated the noise levels in busy streets at three intervals: morning 9 am, early afternoon 3 pm, and 6 pm evening. Among 85 locales, six destinations in the morning period, 52 places in the early afternoon, and 27 places at night surpassed norms set by Pak-EPA. The higher noise level was recorded, i.e., 107.9 dB (A).

Picaut *et al.* [65] suggested an alternative technique for studying the noise environment by adopting the crowdsourcing approach. This technique has developed a smartphone application and a spatial data infrastructure system to get GPS positions, noise indicators, noise levels etc.

3.2 Studies with prominence on urban road traffic noise exposure

It was seen that the most extreme level of zones in metropolitan urban areas fall under severe reasonably to severe conditions [66]. Over and above 100 million individuals in European Union were exposed to road traffic noise surpassing 55 dB (A) inside the large agglomerations and significant road infrastructure [67]. Traffic noise dramatically affects people's ambient environment and health; thus, knowledge and control of the parameters affecting it are essential [68].

Johnas Bazaras *et al.* [69] found that traffic streams in the urban area, especially in city centres, are intensive and uneven; moreover, measured noise levels outreach allowable limits.

Urban road traffic noise is a noise emitted from every source except occupational noise exposure at working place and other environmental noise exposure. The following table describes urban traffic noise.

Banerjee *et al.* [28] observed discrete noise descriptors to delineate the effect on nearby occupants of Asansol city, India, due to road traffic noise. Investigation of noise effect and noise maps were studied. The connection with traffic noise levels and irritation was observed utilising connection, straight, and different direct relapse investi-

Table 2: Urban road traffic noise keywords indicating suitable types of noise exposure

Pavement noise	Engine vibration	Noise from vehicle windows	Musical horn
Tyre noise	Noise from the HVAC system	Traffic noise	Rash driving
Engine noise	Noise from car tape	Noise from ambulance	Rumble strip noise
Horn honking	Tyre pavement interaction noise	Noise from A.C.	Indicator noise
Driver behaviour	Rolling noise	Noise from Silencer	Noise from road construction equipment
Tire squeal	Noise from the exhaust system	Air noise	Vehicles idling noise at signals

gations. The results showed noise record-based models enriched with better disturbance expectations than vehicular information-based models. They distinguished two immediate effects of traffic noise contamination: discourse obstruction during the day and rest aggravation during the night. It was accounted for that the most extreme Leq level for daytime and evening was 89.0 dBA and 81.9 dBA, separately.

Santika *et al.* [30] discussed environmental noise that affects the quality of life, generally contributed by highway traffic, trains, aeroplanes, and industrial activities. Highway noise makes an overall impact, apart from other sources that impact some regions. Dwellers of these areas near the highway are likely victims of the noisy effect. They conducted a test in one of the private schools confronting the road that makes a significant noise level. The noise generated from the traffic flow was 87 dB (A), even though, as indicated by the prescribed noise level, it must be lower than 55 dB (A) for school. Noise may cause to diminish the ability to hear and affects learning.

Othman *et al.* [59] studied that transverse rumble strips can expand traffic noise, indices values, and annoyance reactions in the community. Noise indices were exceeded the proposed level of Traffic Noise Index for planning purposes for 74 dBA for 3% annoyance from the social overviews. Foreseen irritation reaction investigation also showed that occupants in both areas robustly responded to the strong effect of a strong community response. This was in concurrence with the respondent's genuine reaction.

Transverse rumble strips cause an increase in noise levels and disturbance and may lead to an increase in traffic noise index values and annoyance response in the communities [70–72].

Yadav and Tandel [73] studied the exposure effects of traffic noise on Surat city's roadside shopkeepers. The author reported that the equivalent noise level in that study area was 78 dB (A) due to high volume traffic, which is very high and exceeds the prescribed norms. It was observed that people in this region are less or moderately affected by noise pollution; it may be due to less awareness of noise pollution and its effects.

Wen *et al.* [74] researched the effect of urban road traffic on the road schools' acoustic environment through both in-field measurement and on-location study surveys. Six schools were focused on, situated close to different roads in a model city, Taiyuan, in China. Before starting school, they measured the noise levels at study rooms and in the schoolyard. The outcomes demonstrated that noise pollution in these side of the road schools was genuine, and the school noise levels were essentially related to the traffic noise. The most extraordinary estimated identical A-weighted sound level (LAeq, 20min, LAeq) was 74.2 dB(A) close to a freeway, which is 35% higher than (55.0 dB(A)) suggested by the WHO. It was noticed that students felt annoyed by the traffic noise, and the level of disturbance increased with an increase in traffic level.

Koushki *et al.* [2] measured the noise levels inside the transit bus in Kuwait and passenger attitude related to noise exposure and effect. They measured noise in 115 random transit buses and monitored for 64 hours. At the same time, the author measured the attitude of 679 passengers about the level of annoyance and their awareness towards the health and welfare impacts of noise. They concluded that nearly 65% of the passengers were disturbed by the buses inside noise, while 34% were highly annoyed.

Ahmed *et al.* [75] assessed the predominance and seriousness of NIHL in truck drivers of the Mazandaran region in northern Iran. Clinical and para-clinical inspection of 2283 drivers was done in this research work, including estimating their fasting glucose, cholesterol levels, and triglyceride. All members were assessed for the air and bone limits of the two ears. Information from 2260 drivers was examined utilizing SPSS-18. Finally, 37.5% and 41.8% of the drivers had hearing loss in the right and left ear, respectively, due to at least one sound frequency. Drivers of front-mounted motor buses are at high risk concerning noise [75].

3.3 Studies with prominence on urban road traffic noise modelling and mapping

Mine and Sevtap developed a prediction model that gives annoyance levels due to road traffic noise. They considered urban development, social aspects, and traffic characteristics, and the model provides cost-efficient action plans because it identifies the factors that affect annoyance levels [76].

Rajkumara *et al.* developed a traffic noise forecast model interfering with traffic stream. They concluded that street traffic noise is a significant worry of people living in metropolitan regions. This review survey helps to assess the natural impacts of street traffic noise through interference with traffic streams in urban spaces of urban areas in India [77].

Noise expectation models can be utilized for homogeneous street traffic conditions that are not effectively appropriate in heterogeneous street traffic conditions [78]. The forecast model can assist with keeping up with the acoustic environment [79].

Heutschi *et al.* [80] evaluated the tire noise information and the European Road Traffic Noise Emission Model known as CNOSSOS, and they deduced that noise could be reduced by using low-noise tires. Roadway noise is a composition of propulsion noise, rolling noise, and wheel roughness is the significant parameter affecting noise.

Oyedepo [81] used ArcGIS 10.5 to map noise pollution levels in Ota metropolis, Nigeria. Noise maps were generated based on computed equivalent noise values for the decided locations. They concluded A-weighted sound level, the background noise level, i.e., L10, and the high noise level-L90 differ with time and location due to traffic characteristics.

Velaga *et al.* [82] developed noise prediction models, giving the noise level while travelling in motorized vehicles in Mumbai City, India. They studied various aspects such as traffic volume, vehicle speed, road characteristics, etc., affecting noise levels. They observed that in-vehicle noise levels were higher than 70 dB for 50% of a person's commute. Finally, they stated that drivers use horns due to lack of enforcement and congestion, which generally cause more noise levels like above 90 dB.

Shukla *et al.* [83] studied integrated regression equations for selected locations depending on land use. The integrated model is further validated with the FHWA noise prediction model. The results achieved by the FHWA model were surprisingly near the observed noise levels. The model was reasonable for other comparative metropolitan urban communities in India.

Zannin *et al.* [84] noticed the highway's construction and maintenance noise impact. They applied noise barriers simulation by calculating noise maps. Also, they evaluated the effectiveness of noise barriers utilizing ANN combined with the design of experiments. They found an error in the z-score for the estimators. The correlations among the DoE-z and ANN-z significance of ranking for the T.L. and AS responses were R^2 = 0.99887 and R^2 = 0.9877, respectively. Finally, they stated that the absorption coefficient strongly influences noise barriers' noise attenuation.

De *et al.* [85] developed a fuzzy logic to analyze the noise hazard afterwards compared with experiments. They also viewed the normality and non-normality in participation for different noise factors boundaries, primarily exposure time, noise level, and influenced age group of a specific place.

Ranpise and Tandel [52] developed an MLR model of traffic noise at Surat city's major urban roads. They consider commercial and residential areas for noise monitoring, and the traffic condition was heterogenic. The outcome shows a higher noise level accomplished on the flexible pavement surface during peak hours, and it was 4.6 dB(A) which was more than the rigid surface. At last, they reasoned that the equivalent noise level isn't linearly dependent on independent parameters like traffic count and average structure height; the MLR models created untrustworthy and weak. To control this problem, various soft computing tools like neural networks, genetic algorithms, etc., may be used to develop traffic noise prediction models.

Garg *et al.* [86] demonstrated the utilization of an artificial neural network to predict the equivalent sound level (LAeq) and (L10). A back-propagation-based neural network was prepared, approved, and tried utilizing the deliberate information. The comparison shows that neural networks out-play the multiple linear regression models developed to complete the traffic stream and equal traffic stream. Finally, they concluded that the model could predict hourly traffic noise levels, and it was a crucial device for traffic noise prediction and noise mitigation measures for a Delhi city.

Lisle [87] investigated the correctness in the prediction of calculation of Road Traffic Noise, Traffic Noise Model-2.5, Noise Propagation Computation Method Including Meteorological Effects, and Acoustical Society of Japan-Road Traffic Noise. They compared all models distinctly for each procedure with noise monitoring values and constructed a test case model to verify each method's composition of ground effect and shielding. As they studied, the predictions for CoRTN are doubtful since predicted noise levels for soft ground are equal to hard ground. They deduced that

ASJ RTN resulted from high under-prediction and CoRTN resulted in high over-prediction.

Hamad *et al.* [88] adopted the ANN technique to model road traffic noise in Sharjah city with a known hot climate in the UAE. They collected 420 (hourly) measurements of noise levels from three different road sites of the city. A total of 16 feed-forward backpropagation Artificial neural network models with single and double hidden layers were considered for the study compared with two conventional models, such as the Basic Statistical Traffic Noise Model and Ontario Ministry Transport Road Traffic Noise model. They concluded that ANN models outperformed the traditional model.

Sonaviya and Tandel [4] generated noise maps to understand urban road traffic noise propagation. They used Sound- PLAN software to design noise maps. They concluded that in a developing country such as India, traffic composition is heterogeneous, and it contains the different sizes of vehicles, speeds of vehicles, and working frameworks. Due to fluctuating speed, lack of path disciplines, and non-approved stopping on primary street paths, honking events are unavoidable, which changes and influences the metropolitan soundscape of India. Due to horn occasions heterogeneous traffic conditions, noise level (LAeq) increment by 0.5–8 dB (A) compared with homogeneous traffic conditions.

3.4 Studies with prominence on urban road traffic noise mitigation strategies

The noise pollution impact can be reduced by adequately preparing and enforcing laws and regulations to control noise sources and methods and operation places. Such action has to start within the limited authority at the federal level.

The main effects of traffic noise on people are annoyance, fatigue, speech interference, distraction, and reduction inefficiency. These effects depend on the individual's sensitivity to noise and their age. Traffic noise disturbs the quality of sleep and, in some people at least, may lead to insomnia. Social pleasure derived from the conversation, listening to the radio and tape recordings, and watching the television become increasingly difficult as the disturbance from the outside road traffic noise increases; hence to reduce the impact of noise, it is necessary to adopt various mitigation strategies [82, 89, 90].

Parida *et al.* [91] designed a noise barrier using an artificial neural network. The calculation of the height of a highway noise barrier was done. They studied traffic volume, noise level, vehicle speed, and site geometry data. For design, the height of the noise barrier was shifted from 2-5 m in increments of 0.1 m for each measured data set to get theoretical data. At every height increment, barrier depletion was calculated using the Federal Highway Administration model; they stated, a noise barrier can attenuate about 20 dB(A), but in practice, this limit is around 15 dB(A). The designed barrier in the present work provides an attenuation of about 15 dB(A). They finalised the noise barrier height to achieve the desired noise level (Leq) of 4.8 m.

Liu *et al.* [92] proposed reducing urban traffic noise with vegetated roofs. They studied the sound absorption performance of vegetated roofs affected by their substrate water content. The author observed a notable decrease in noise reduction when the substrate water content increased, explicitly in the frequency range between 250 Hz and 1250 Hz. They saw that the clearest drops in noise reduction happen at the frequencies between 400 Hz and 1600 Hz as the VWC value increments from 0.20 to 0.25m3/m3, with the most significant decrease of 7 dB for the 1250 Hz 1/3 octave band.

One can utilize low cost, biodegradable natural materials for the vehicle's HVAC framework to control the noise. Jute felt and waste cotton has higher sound ingestion coefficients than ordinary sound engrossing regular materials. The author has picked this material as solid safeguards for noise control treatment of a model HVAC unit. They did the sound quality assessment with 24 members and showed that the treatment essentially decreased the irritation of the vehicle inside the soundscape involving the HVAC noise. At last, they inferred that waste cotton and Jute felt are minimal expense, biodegradable, lightweight, and recyclable natural materials with high potential for HVAC noise control [93].

Laib *et al.* [42] examined which noise reduction level can be achieved using electric buses in urban areas. They conducted extensive sound estimations on three different buses with traditional and electric drive concepts. The noise profiles were applied into a sound propagation model, and the noise levels were determined along with acceptable bus routes in Stuttgart, Germany. A confined examination of the buses reveals a critical sound level difference of up to 14 dB (A) at low speeds. They derived that noise reduction utilizing the electric buses is firmly based on the extent of buses on the route and in quiet residential areas; the average noise reduction when using electric buses was up to 5 dB (A).

Vladimir [94] studied urban development trends in residential and non-residential areas and optimized its design to acquire expanded acoustic solace, particularly inside dwellings. They introduced the methodology concerning the noise problem rather than considering sound insulation material and strategies. They studied two locations in some noisiest regions concerning railroad noise pollution and traffic noise. For estimating, a full-range sound analyzer was used to give noise levels to a 1/3 octave, the full range from 20 Hz-20 kHz. Using a total spectrum analyzer rather than an ordinary sound level meter, they saw the spectrum's main problematic zones to give appropriate solutions and show what frequencies have the most significant levels [95].

Kim [96] investigated the effect of vegetation on noise reduction and the changes in the soundscape of an access road to a religious space in Seoul, Chungbuk, South Korea. They investigated noise propagation by performing field measurements before vegetation was covered with soil, one month after, and four years after vegetation. The overall soundscape perception was studied by conducting a social survey. To understand the effects of vegetation on the acoustic environment, acoustical measurements were taken simultaneously along the access road before and after vegetation.

Ow [97] studied the roadside vegetation's impact on decreasing road traffic noise under fluctuating planting forces. The outcomes indicated that the noise level reduction could be achieved by half when vegetation was improved from a minor to moderate planting force. No upgrade in noise decrease was seen as the vegetation was additionally increased to a thick power. At 5 m depth of vegetation barrier, it was seen that a perfect depth for traffic noise decrease. Without vegetation, the observed mean noise levels were 78 dB; conversely, vegetative boundaries such as moderate to thick had the option to diminish traffic noise by 9–11 dB.

Gil Lopez *et al.* [98] determined and assessed the utilization of a mixture of dead palm tree pruning waste with dampened topsoil in the noise barrier development. Using pruning waste and eco-friendly material that doesn't cause any natural dangers toward the finish of its useful life, the arrangement offering the best sound absorption has been analyzed. This investigation exhibits that the eco-friendly noise barrier performs well in noise absorption.

Vaitkus *et al.* [99] assessed traffic noise reduction under modified asphalts pavements in Lithuania; they investigated noise-reducing asphalt for Lithuanian environment conditions described as a harsh climate with a high number of yearly ice defrost cycles. The improvement of conventional asphalt mixtures SMA and A.C. were performed to build noise reduction properties while maintaining durability. The increase of porosity leads better sound absorption and reduction of tire pavement sound at high frequencies (more than 1000 Hz).

Noise reduction of such asphalts can be achieved by 5–8 dBA, but its loose initials noise reduction properties quickly (around one dBA each year) because of soil in the voids. Results show that developed noise-reducing asphalts will reduce traffic noise from 2 to 4 decibels compared with conventional SMA and A.C. mixtures [100, 101].

Renterghem *et al.* [79] reviewed ways of reducing surface transport noise by natural means. The noise mitigation can be achieved by landscaping and planting trees around the urban environment. They incorporate vegetated surfaces applied to faces or tops of noise walls and buildings' façades and roofs, tree belts, shrub zones, edges, earth berms, and various exploiting ways ground-surface-related effects.

Kim *et al.* [102] proposed an assessment system utilizing a scale model to concentrate on the noise reduction impacts of sustainable metropolitan structure designs' vegetated facades. The absorption coefficients of the scale-model materials were calculated to fit the absorption qualities of natural vegetation. The ground impedance of asphalt was estimated to deduce the acoustic properties of ground surfaces and select the ground material. The impacts of adding vegetated facades were assessed in the scale model of a street canyon. At last, they derived that the noise decreases because the vegetated facades were under 2 dB at the pedestrian level in a two-lane street canyon.

Halim [103] investigated the effectiveness of different existing noise barriers in the Klang Valley region. They studied vegetation, hollow concrete block, and panel concrete noise barriers in three urban residential areas. They calculated insertion loss dependent on the ISO 10847:1997 and ANSIS 12.18-1994 to comprehend the viability of noise barriers. During weekdays, insertion loss recorded by vegetation ranged from 0.3 and 2.2 dB (A). The hollow concrete blocks recorded the broadest range of insertion loss from 4.5 and 9.4 dB (A). The noise barriers of vegetation, hollow concrete blocks, and precast concrete panel recorded insertion loss went between 0.2 and 1.5 dB (A), 3.8 and 9.2 dB(A), and 7.0 and 8.4 dB(A) separately during ends of the week. The precast concrete panel showed steady insertion loss values that surpassed the minimum insertion loss value in the scope of 5.8 to 8.2 dB (A) for all measurements.

Hornix *et al.* [104, 105] performed a numerical examination of sound propagation over the open highest points of the middle of the street canyon using the parabolic equation and equivalent sources methods. Sound levels in safeguarded regions, like canyons between structures, are firmly affected by far off sources. The noise reduction from −1 dB to −4 dB for each canyon on both a 1/3-octave band and A-weighted basis. Facade absorption is the best when put in the upper piece of the canyon and can typically reduce 4 dB (A). Building 1 m wide walkways with roof absorption reduce the level generally by 3 dB (A). These impacts are best for narrow canyons...

An effectively controlled thin barrier might give preferred noise reduction results over typical passive solutions. The performance of a particularly active technique has been affirmed by utilizing a committed noise dropping lab casing. This methodology is applied to actual device casing, a significant step towards commercializing the dynamic casing technique [106–108].

Torres [109] presented new open noise barriers called "Sonic Crystal Acoustics Screens" based on the sonic crystal. At SCAS, there are three noise control mechanisms B.G., absorption, and resonances. These new SCAS introduce a necessary technological procedure in acoustic barriers. These new devices have shown an excellent auditory response because of the standardization results, indicating that they can compete acoustically with classical A.B.s. For that reason, SCAS can be used in noise control to reduce the most critical type of noise that appears in cities: transport noise.

Lacasta *et al.* [110] evaluated a modular green noise barrier; In situ estimations of noise, reflection was performed utilizing a test model to appraise the sound absorption coefficients. These coefficients were found to have around 0.7, higher than those recently found in laboratory estimations for a comparative framework with a lower vegetation thickness. The achieved values were input into programming for anticipating environmental noise to investigate the expected performance of such barriers, especially in a pair of equal barriers. Reflective walls show a significant improvement in sound attenuation of up to 4 dBA.

Wesler [111] deduced that surface transportation creates most of the noise pollution imposed on our communities today. Adequate preparation and enforcement of regulations are required to control noise sources.

3.5 Effect of COVID pandemic on traffic noise

Zambon *et al.* [112] presents the effects of COVID-19 outbreak on the sound environment of the city of Milan, Italy. To restrict the dispersion of the pandemic, Italy took on developing levels of prohibitive measures, which finished with a 41-day lockdown from March 23 to May 3, 2020. This activity established another sort of environment including a significant decrease of air, water and soil pollution, along with partial recovery of the biological systems. A permanent noise monitoring system created of 24 sensors installed in the city which permitted catching the changes in sound environment in a pre, during and post-lockdown period. The examination of the noise levels as far as both outright noise levels (Lden) and hourly noise profiles with a similar time of 2019, showed an emotional decrease of the noise levels of roughly 6 dB.

Manzano *et al.* [113] they studied some iconic sites in Granada, Spain, before (2019) and during the covid lockdown (2020). Finally, the concluded that there was a considerable change in environmental noise levels and it was due to its magnitude and implications, also, especially at those sites where social human activity was an identity feature. Important spectral changes were observed before and during the covid lockdown, suggesting a shift from anthropic to animal sources in the acoustic environment.

De Lauro *et al.* [114] observed the noise levels of Fontana di Trevi metropolitan in Rome, Italy, and identify how it interacts with other features. The spectral sound print obtained was different to the one determined in a time period far from the lockdown, the latter showing additional components in the 0.7-1 kHz band frequency, which seems to act as a synchronization mechanism. The one of a kind Covid-19 "quiet" let arise sounds that had been in the spot for a really long time, and offered the likelihood to report them for safeguarding issues and social legacy.

Spennemann *et al.* [115] bring up that a symptom of the sensational social and conduct change brought about by government reactions to COVID-19 has been an emotional transitory modification of metropolitan social soundscapes. They consider the nature and degree of these soundscapes and investigate how much the COVID-19-initiated reality can be utilized to extend a future of metropolitan social soundscapes on the off chance that no dynamic legacy mediation was to happen.

Sakagami [116] shows the results of a subsequent noise study in a silent residential zone in Japan during the lockdown and half a month (June 2020) after the abrogation of the state of emergency. Since the outcomes are practically something similar, the author induces that either the noise level was diminished in June to a level that was practically equivalent to that during the highly sensitive situation, or the noise level after its cancellation in May was potentially higher than expected.

Kalawapudi *et al.* [117] report the correlation of noise lists (LA10, LA50, LA90, noise pollution level LNP and NC still up in the air in 2020 during the Ganesh Chaturthi celebration in Mumbai city, India, what's more, those gathered in the earlier years of 2018 and 2019. The celebration festivity in eco-friendly way due to COVID-19 limitations prompted huge reduction in noise levels, in excess of 25 dB (A) in LAeq.

Mishra *et al.* [118] studied the impact of noise pollution in Kanpur city during covid-19 pandemic situation. They observed that the average noise levels before lockdown and during lockdown were found to be in the range of 44.85 dB to 79.57 dB and 38.55 dB to 57.79 dB respectively, for different zones. This study also studied the impact of noise pollution i.e., Percentage annoyance and sleep disturbance during and before lockdown.

Gevú *et al.* [119] presents a comparison between the acoustic scenario at the Rio de Janeiro city center, before and during the COVID-19 pandemic. Comparison consisted of analyzing measured data and noise maps produced for the city center area. The maps were developed according to measured and collected data of the respective time periods. The comparative analysis showed a considerable noise reduction, between 10 and 15 dB, for areas where the traffic noise was not intense and where the human activities were predominant on the streets. However, there was no substantial noise decrease for the areas around the major avenues. This occurred due to the traffic intensity drop to 50% during the pandemic, which meant a noise reduction between 3 and 5 dB.

4 Cluster analysis of the examined papers

The study analyses 175 papers containing the term "urban road traffic noise" "Noise mitigation strategies", "noise modelling", "noise mapping", "noise exposure", "noise barrier" in the title or keywords. The VOS viewer software was (http://www.vosviewer.com) utilized to generate clus-

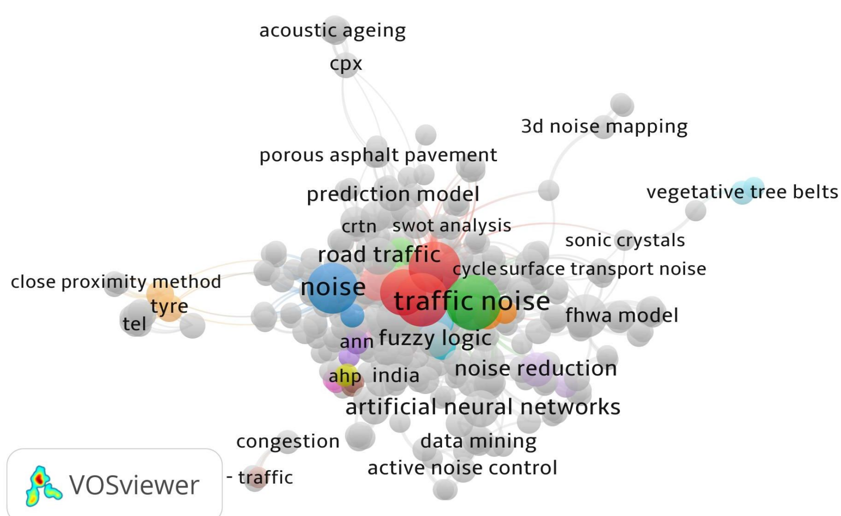

Figure 1: Network visualization of the cluster analyzing literature

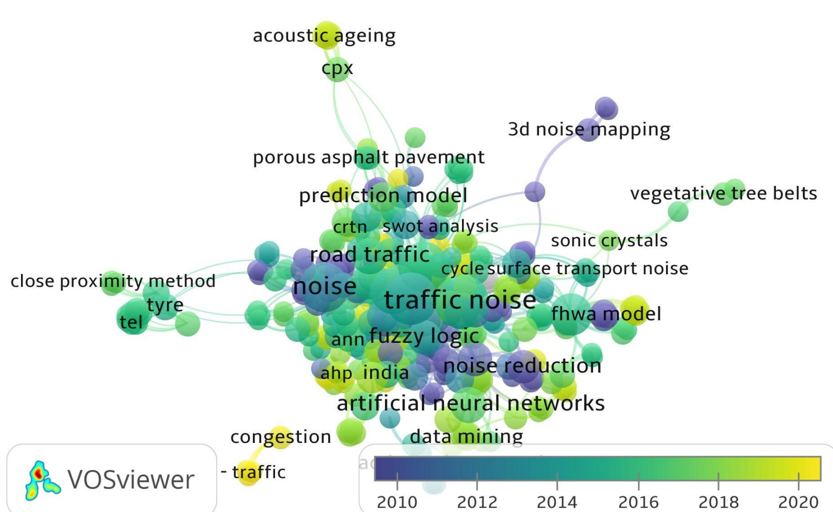

Figure 2: Overlay analysis of examined papers showing the publication year

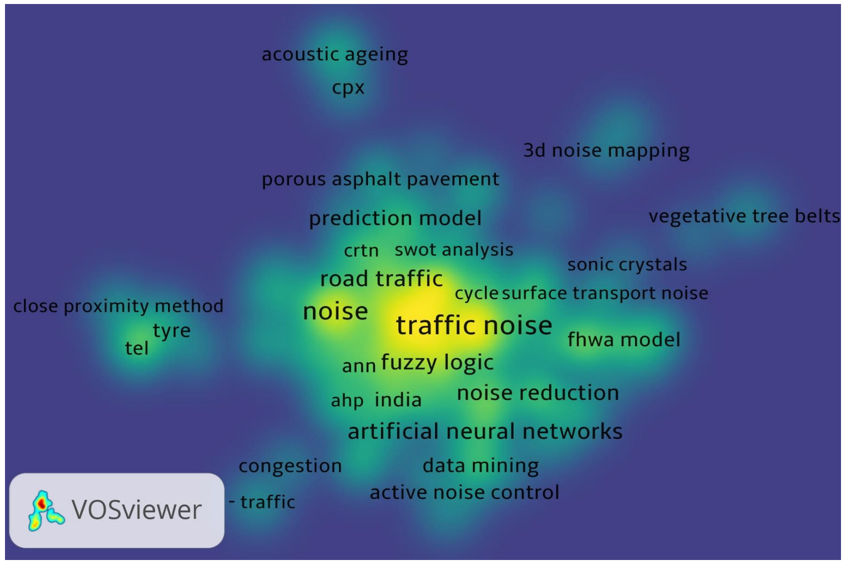

Figure 3: Density visualization

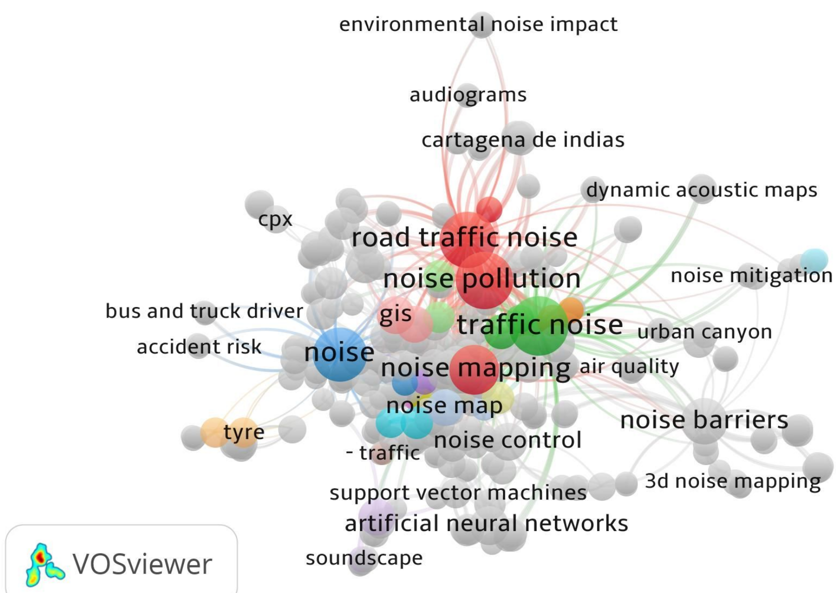

Figure 4: Network visualization association with strength

tering maps examining the network of co-citation, or of co-occurrence of the terms in various sources.

The input data for VOS viewer was the Research Information System (RIS) file which was extracted from Mendeley reference manager software. The downloaded literature was transfer in a folder and added in the inventory of Mendeley then in the "file" tab there is option to export all and then clicked on (*.ris) RIS file. This file utilized for cluster mapping.

4.1 Network visualization

It represents the article with circle whose size based on their weight and the color-code shows the membership to a specific cluster [51]. Also, the links between the items represents the distance between two articles for their relatedness in term of co-occurrence in various papers or titles.

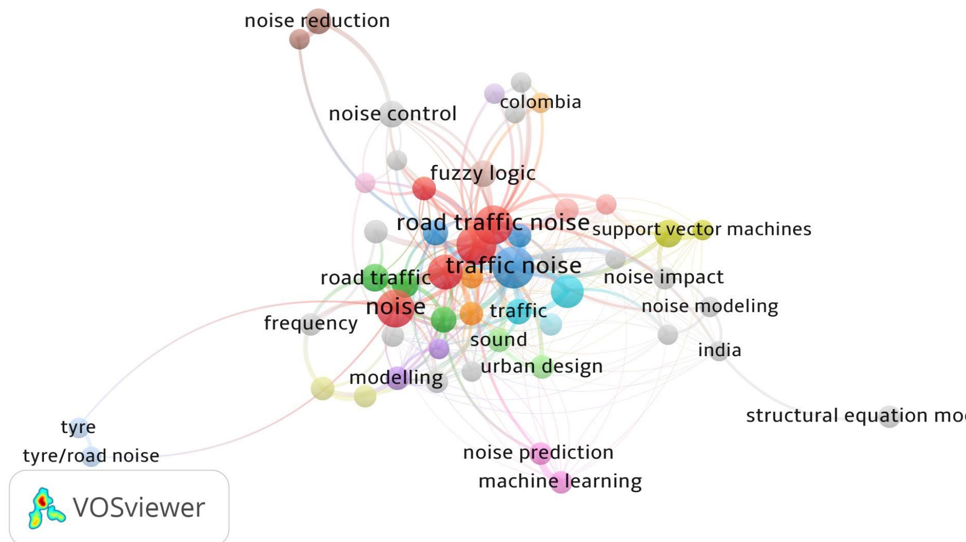

Figure 5: Network visualization (Keyword, co-occurrence, fractional counting)

4.2 Overlay visualization

It is similar to network visualization, but articles not covered on the basis of clustering membership but following the score. It is explained in Figure 2 and it showing the publication year of the paper they belong to.

4.3 Density visualization

It provides a quick overview of the main areas in a bibliometric network.

5 Conclusions and recommendations for future work

This review paper attempts to establish a thematic assessment of urban traffic noise studies focusing on urban traffic noise. This study focuses on the review to understand the urban traffic noise by virtue of monitoring [120], mapping, modelling [121] and mitigation strategies [7, 36] used in various parts of the world. Also, this study presents cluster analysis which introduce some significant pictures in the paper. The main reason for the increment in noise level is urbanization and industrialization. In advanced economies such as the United Kingdom, United States, and Australia, passenger vehicles contribute to general traffic noise, particularly along high-speed roads [29, 72, 122]. In contrast, in developing countries such as India, Thailand, China, and Vietnam, the motorcycle usage rate is several folds higher than cars, so not only are motorcycles the main contributors to traffic noise, honking noise is also a prominent feature [122].

In a first-world country such as Australia, while heavy vehicles contribute less to time-averaged sound levels, they are considered more disturbing than passenger vehicles because of propulsion noise even along high-speed roadways [124–126].

This review paper preferred about sixty-seven relevant articles on urban road traffic noise for critical review. This study is classified into six categories such as noise monitoring, noise impact, modelling of traffic noise, noise barrier, and various noise mitigation strategies. Only 5.97% of articles describe how to monitor and record the noise measurement for urban roads correctly, and it gives a clear idea about noise monitoring. About 7.46% of articles enumerated the exposure effect of urban traffic noise pollution with good explanation. Approximately 29.85% of articles proposed evaluation procedures using the model to assess the noise reduction effects and predict the noise level, which helps noise attenuation. In comparison, 56.71% of articles reported noise mitigation strategies and abatement plans, which give a clear idea about optimized noise barriers, noise control window design, vegetative barriers, and low noise tire pavement material.

In thirty-eight reviews, noise mitigation strategies are described. Out of these thirty-eight studies, only three studies adequately explained noise mitigation through vegetation, and in 20 studies, noise modelling and noise mapping were executed. The rest of noise mitigation through pavement surface and other materials has been undertaken to study noise control. Some articles reported, green-belt effectively reduces the noise. According to some authors, a vast plantation inside the compound protects the house from vehicular traffic noise. Only three studies were done in the lab; the rest of all reviews had covered field surveys. Barely four-five articles reported using a large sample size, which may be helpful in better analysis. Various statistical methods and models were used in their studies. Most of the reviews give an idea about the noise prediction model and noise barrier. Some studies explained noise monitoring and establishing a diversified noise monitoring network. As per the standards, many articles reported that the decibel level in silence zones should not exceed 50 dB during the day and 40 dB during the night. But, sound levels at the various sites are continuously increasing.

Specific legislation and guidelines should be proposed for noise mitigation planning and activity to incorporate vibration control, sound-evidence cabins, and sound-retaining materials [127–129]. A green belt of vegetation and open spaces, as a rule, may have high value in noise control in a metropolitan region as in air cleaning. It has been seen that plants are efficient absorbers for high-frequency noise.

There is a need to make an acoustic structure [9] and organized rules to decline and reduce unwanted sound. Regulations and standards for noise mitigation and acoustic arrangement are not ordinary, and investigation is essential when one is occupied with land-use planning and environmental management programs [13]. A purposeful effort is required to combine noise thought in developmental planning. Rapidly and successfully assessing an urban acoustic condition's quality is a significant test for urban planning and management authority [127].

A review of research papers of the most recent studies exhibited research gaps. Appropriately, it also gives out the following future points in the view of noise pollution research.

- Each future study should efficiently analyze noise level assessment and its effects in noise sources, exposure effect analysis, and efficient noise control strategy.
- The investigator should focus on the exposure effect relationship of urban traffic noise, considering a higher sample size in the future study.
- There is a need to properly investigate the noise level in the silence zone and find out the optimized solution to control the noise in these areas.
- A more effective study on noise control through vegetation and landscape planning, low cost and indigenous noise barrier should be carried out for developing countries.
- A multidisciplinary approach for noise mitigation in urban areas should be adopted by integrating transportation planning, urban planning, and acoustic engineering.

Funding information: The authors state no funding involved.

Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Conflict of interest: The authors state no conflict of interest.

References

[1] Tandel BN, Macwan JE. Road Traffic Noise Exposure and Hearing Impairment Among Traffic Policemen in Surat, Western India. J Inst Eng Ser A. 2017;98(1–2):101–5.
[2] Koushki PA, Ali MA, Chandrasekhar BP, Al-Sarawi M. Exposure to noise inside transit buses in Kuwait: measurements and passenger attitudes. Transp Rev. 2002;22(3):295–308.
[3] Phelps AH. The Need for Frequency Analysis in the Identification and Solution of Noise Problems. J Air Pollut Control Assoc. 1973;23(1):17–22.
[4] Sonaviya DR, Tandel BN. 2-D noise maps for tier-2 city urban Indian roads. Noise Mapp. 2019;6(1):1–7.
[5] Kalaiselvi R, Ramachandraiah A. Honking noise corrections for traffic noise prediction models in heterogeneous traffic conditions like India. Appl Acoust. 2016;111:25–38.
[6] Freitas EF, Martins FF, Oliveira A, Segundo IR, Torres H. Traffic noise and pavement distresses: modelling and assessment of input parameters influence through data mining techniques. Appl Acoust. 2017 Dec;2018(138):147–55.
[7] Harris RA, Cohn LF. Use of vegetation for abatement of highway traffic noise. J Urban Plann Dev. 1985;111(1):34–48.
[8] Prezelj J, Murovec J. Traffic noise modelling and measurement: inter-laboratory comparison. Appl Acoust. 2017;127:160–8.
[9] Van Renterghem T, Botteldooren D. Landscaping for road traffic noise abatement: model validation. Environ Model Softw. 2018;109(July):17–31.
[10] Licitra G, Gagliardi P, Fredianelli L, Simonetti D. Noise mitigation action plan of Pisa civil and military airport and its effects on people exposure. Appl Acoust. 2014;84:25–36.
[11] Brown AL, van Kamp I. WHO environmental noise guidelines for the European region: A systematic review of transport noise interventions and their impacts on health. Int J Environ Res Public Health. 2017 Aug;14(8):1–44.
[12] Heroux ME, Verbeek J. Methodology for systematic evidence reviews for the WHO environmental noise guidelines for the European region. WHO; 2018. http://www.euro.who.int/en/health-topics/environment-and-health/noise/publications
[13] Ranpise RB, Tandel BN. Noise Monitoring and Perception Survey of Urban Road Traffic Noise in Silence Zones of a

Tier II City—Surat. J Inst Eng India Ser A. 2022;103:155–167. https://doi.org/10.1007/s40030-021-00598-x.
[14] Bu QM, Wang ZJ, Tong X. An improved genetic algorithm for searching for pollution sources. Water Sci Eng. 2013;6(4):392–401.
[15] Zambon G, Roman HE, Smiraglia M, Benocci R. Monitoring and prediction of traffic noise in large urban areas. Appl Sci (Basel). 2018;8(2):251.
[16] Nourani V, Gökçekuş H, Umar IK. Artificial intelligence based ensemble model for prediction of vehicular traffic noise. Environ Res. 2020;180(October 2019):108852. https://doi.org/10.1016/j.envres.2019.108852.
[17] Khan J, Ketzel M, Jensen SS, Gulliver J, Thysell E, Hertel O. Comparison of Road Traffic Noise prediction models: CNOSSOS-EU, Nord2000 and TRANEX. Environ Pollut. 2021 Feb;270:116240.
[18] Garg N, Sinha AK, Sharma MK, Gandhi V, Bhardwaj RM, Akolkar AB, et al. Study on the establishment of a diversified National Ambient Noise Monitoring Network in seven major cities of India. Curr Sci. 2017;113(7):1367–83.
[19] Deng Y, Cheng JC, Anumba C. A framework for 3D traffic noise mapping using data from BIM and GIS integration. Struct Infrastruct Eng. 2016;12(10):1267–80.
[20] Ögren M, Molnár P, Barregard L. Road traffic noise abatement scenarios in Gothenburg 2015 - 2035. Environ Res. 2018 Jul;164(164):516–21.
[21] Debnath A, Singh PK. Environmental traffic noise modelling of Dhanbad township area – A mathematical based approach. Appl Acoust. 2018;129:161–72.
[22] Jamrah A, Al-Omari A, Sharabi R. Evaluation of traffic noise pollution in Amman, Jordan. Environ Monit Assess. 2006 Sep;120(1-3):499–525.
[23] Sadia R, Bekhor S, Polus A. Structural equations modelling of drivers' speed selection using environmental, driver, and risk factors. Accid Anal Prev. 2018 Jul;116(116):21–9.
[24] Alam W. GIS based Assessment of Noise Pollution in Guwahati City of Assam, India. Int J Environ Sci. 2011;2(2):731–40.
[25] Jamrah A, Al-Omari A, Sharabi R. Evaluation of traffic noise pollution in Amman, Jordan. Environ Monit Assess. 2006 Sep;120(1-3):499–525.
[26] Omidvari M, Nouri J. Effects of noise pollution on traffic policemen. Int J Environ Res. 2009;3(4):645–52.
[27] Yeung M, Ng I, Lam J, Tang SK, Lo D, Yeung D. Tackling traffic noise through plenum windows - An application in Hong Kong. INTERNOISE 2014 – 43rd International Congress on Noise Control Engineering; 2014 Nov 16-19; Melbourne, Australia. Australian Acoustical Society; 2014.
[28] Banerjee D, Chakraborty SK, Bhattacharyya S, Gangopadhyay A. Appraisal and mapping the spatial-temporal distribution of urban road traffic noise. Int J Environ Sci Technol. 2009;6(2):325–35.
[29] Zannin PH. Occupational noise in urban buses. Int J Ind Ergon. 2006;36(10):901–5.
[30] Santika BB, Indrawati S. Suyatno, Yahya E. Noise Evaluation of Traffic Flows and Its Effect to Concentration Capability of the Students in One of Private School in Surabaya. Procedia Eng. 2017;170:274–9.
[31] Omlin S, Bauer GF, Brink M. Effects of noise from non-traffic-related ambient sources on sleep: review of the literature of 1990-2010. Noise Health. 2011 Jul-Aug;13(53):299–309.
[32] Goswami S, Swain BK. Environmental Noise in India: A Review. Curr Pollut Rep. 2017;3(3):220–9.
[33] Ali SA, Tamura A. Road traffic noise mitigation strategies in Greater Cairo, Egypt. Appl Acoust. 2002;63(11):1257–65.
[34] Herman L, Bowlby W. Final Technical Report for Research Project "Noise Mitigation Strategies". WA-RD 327.2. Washington State Department of Transportation; 1993.
[35] Licitra G, Moro A, Teti L, Del Pizzo A, Bianco F. Modelling of acoustic ageing of rubberized pavements. Appl Acoust. 2019;146:237–45.
[36] Merska O, Mieczkowski P, Zymełka D. Low-noise Thin Surface Course - Evaluation of the Effectiveness of Noise Reduction. Transp Res Procedia. 2016;14:2688–97.
[37] Ho KY, Hung WT, Ng CF, Lam YK, Leung R, Kam E. The effects of road surface and tyre deterioration on tyre/road noise emission. Appl Acoust. 2013;74(7):921–5.
[38] Barclay M, Kang J, Sharples S. Combining noise mapping and ventilation performance for non-domestic buildings in an urban area. Build Environ. 2012;52:68–76.
[39] Freitas E, Mendonça C, Santos JA, Murteira C, Ferreira JP. Traffic noise abatement: how different pavements, vehicle speeds and traffic densities affect annoyance levels. Transp Res Part D Transp Environ. 2012;17(4):321–6.
[40] Li T. Literature review of tire-pavement interaction noise and reduction approaches. J Vibroengineering. 2018;20(6):2424–52.
[41] Mendonça C, Freitas E, Ferreira JP, Raimundo ID, Santos JA. Noise abatement and traffic safety: the trade-off of quieter engines and pavements on vehicle detection. Accid Anal Prev. 2013 Mar;51:11–7.
[42] Laib F, Braun A, Rid W. Modelling noise reductions using electric buses in urban traffic. A case study from Stuttgart, Germany. Transp Res Procedia. 2018 Sep;2019(37):377–84.
[43] Van Renterghem T, Forssén J, Attenborough K, Jean P, Defrance J, Hornikx M, et al. Using natural means to reduce surface transport noise during propagation outdoors. Appl Acoust. 2015;92:86–101.
[44] De Salis MH, Oldham DJ, Sharples S. Noise control strategies for naturally ventilated buildings. Build Environ. 2002;37(5):471–84.
[45] Sharifzadeh Mirshekarloo M, Tan CY, Yu X, Zhang L, Chen S, Yao K, et al. Transparent piezoelectric film speakers for windows with active noise mitigation function. Appl Acoust. 2018;137(February):90–7.
[46] Rosenhouse G. Charts for acoustic design of rooms exposed to outdoor and indoor noise. Appl Acoust. 1987;22(2):117–29.
[47] Fredianelli L, Del Pizzo A, Licitra G. Recent developments in sonic crystals as barriers for road traffic noise mitigation. Environments. 2019;6(2):14.
[48] Chen L, Zhao W, Yuan X, Zhou B. Study on the Optimization of the Distribution of Absorbing Material on a Noise Barrier. Acoust Aust. 2018;46(1):119–30.
[49] Toledo R, Aznárez JJ, Maeso O, Greiner D. Optimization of thin noise barrier designs using Evolutionary Algorithms and a Dual BEM Formulation. J Sound Vibrat. 2015;334:219–38.
[50] Kasess CH, Kreuzer W, Waubke H. Deriving correction functions to model the efficiency of noise barriers with complex shapes using boundary element simulations. Appl Acoust. 2016;102:88–99.
[51] Grazieschi G, Asdrubali F, Guattari C. Neighbourhood sustainability: State of the art, critical review and space-temporal analysis.

Sustain Cities Soc. 2020;63:102477.
[52] Ranpise RB, Tandel BN, Darjee C. Assessment and MLR Modeling of Traffic Noise at Major Urban Roads of Residential and Commercial Areas of Surat City. In: Kumar S, Kalamdhad A, Ghangrekar M, editors. Sustainability in Environtal Engineering and Science. Singapore: Springer; 2020. https://doi.org/10.1007/978-981-15-6887-9_21.
[53] Kumar P, Nigam SP, Kumar N. Vehicular traffic noise modeling using artificial neural network approach. Transp Res, Part C Emerg Technol. 2014;40:111–22.
[54] Licitra G, Teti L, Cerchiai M, Bianco F. The influence of tyres on the use of the CPX method for evaluating the effectiveness of a noise mitigation action based on low-noise road surfaces. Transp Res Part D Transp Environ. 2017;55:217–26.
[55] Akhtar N. Kafeel Ahmad SG. Road Traffic Noise Mapping and a Case Study for Delhi. Int J Appl Eng Technol. 2012;2(4):39–45.
[56] Tandel BN, Jem M. Assessment and MLR Modeling of Urban Traffic Noise At Major Arterial Roads of Surat, India. J Environ Res Develop. 2013;7(4A):1703–9.
[57] Staiano MA. Tire–Pavement Noise and Pavement Texture. J Transp Eng Part B Pavements. 2018;144(3):04018034.
[58] Tian B, Liu Y, Niu K, Li S, Xie J, Li X. Reduction of tire-pavement noise by porous concrete pavement. J Mater Civ Eng. 2014;26(2):233–9.
[59] Othman MH, Haron Z, Mohd Yusof MB, Hainin MR, Yahya K, Yaacob H, et al. Evaluation of external noise produced by transverse rumble strips on rural roadways. Adv Mater Res. 2012;446–449:2617–23.
[60] Vijay R, Sharma A, Chakrabarti T, Gupta R. Assessment of honking impact on traffic noise in urban traffic environment of Nagpur, India. J Environ Health Sci Eng. 2015;13(10).
[61] Staiano MA. Tire-pavement noise and pavement texture. J Transp Eng Part B Pavements. 2018;144(3):1–10.
[62] Abbaspour M, Golmohammadi R, Nassiri P, Mahjub H. An investigation on time-interval optimisation of traffic noise measurement. J Low Freq Noise Vib Act Control. 2006;25(4):267–73.
[63] Laxmi V, Dey J, Kalawapudi K, Vijay R, Kumar R. An innovative approach of urban noise monitoring using cycle in Nagpur, India. Environ Sci Pollut Res Int. 2019 Dec;26(36):36812–9.
[64] Rahman Farooqi ZU, Nasir MS, Nasir A, Zeeshan N, Ayub I, Rashid H, et al. Evaluation and analysis of traffic noise in different zones of Faisalabad – an industrial city of Pakistan. Geol Ecol Landscapes. 2017;9508(4):1–9.
[65] Picaut J, Fortin N, Bocher E, Petit G, Aumond P, Guillaume G. An open-science crowdsourcing approach for producing community noise maps using smartphones. Build Environ. 2018 Jul;2019(148):20–33.
[66] Pandya GH. Urban noise—a need for acoustic planning. Environ Monit Assess. 2001 Mar;67(3):379–88.
[67] European Environment Agency. Noise in Europe 2014. EEA Report 10/2014. 68 p.
[68] Freitas EF, Martins FF, Oliveira A, Segundo IR, Torres H. Traffic noise and pavement distresses: modelling and assessment of input parameters influence through data mining techniques. Appl Acoust. 2018;138(March):147–55.
[69] Bazaras J, Jablonskyte J, Jotautiene E. Interdependence of noise and traffic flow. Transport. 2008;23(1):67–72.
[70] An DS, Kwon SA, Lee J, Suh YC. Investigation of Exterior Noise Generated by Vehicles Traveling over Transverse Rumble Strips. J Perform Constr Facil. 2017;31(2):1–11.
[71] Karkle DE, Rys MJ, Russell ER. Centerline rumble strips: study of external noise. J Transp Eng. 2011;137(5):311–8.
[72] Yadav M, Tandel B. Exposure effect study on traffic noise on roadside shopkeepers in Surat city. Indian J Environ Prot. 2019;39(11):1038–1045.
[73] Wen X, Lu G, Lv K, Jin M, Shi X, Lu F, et al. Impacts of traffic noise on roadside secondary schools in a prototype large Chinese city. Appl Acoust. 2019;151:153–63.
[74] Alizadeh A, Etemadinezhad S, Charati JY, Mohamadiyan M. Noise-induced hearing loss in bus and truck drivers in Mazandaran province, 2011. Int J Occup Saf Ergon. 2016;22(2):193–8.
[75] Ascigil-Dincer M, Yilmaz Demirkale S. Model development for traffic noise annoyance prediction. Appl Acoust. 2021;177:107909.
[76] Rajakumara HN, Mahalinge Gowda RM. Road traffic noise prediction model under interrupted traffic flow condition. Environ Model Assess. 2009;14(2):251–7.
[77] Sonaviya DR, Tandel BN. Integrated road traffic noise mapping in urban Indian context. Noise Mapp. 2020;7(1):99–113.
[78] Van Renterghem T, Forssén J, Attenborough K, Jean P, Defrance J, Hornikx M, et al. Using natural means to reduce surface transport noise during propagation outdoors. Appl Acoust. 2015;92:86–101.
[79] Heutschi K, Bühlmann E, Oertli J. Options for reducing noise from roads and railway lines. Transp Res Part A Policy Pract. 2016;94:308–22.
[80] Oyedepo SO, Adeyemi GA, Olawole OC, Ohijeagbon OI, Fagbemi OK, Solomon R, et al. A GIS – based method for assessment and mapping of noise pollution in Ota metropolis, Nigeria. MethodsX. 2019 Feb;6:447–57.
[81] Konbattulwar V, Velaga NR, Jain S, Sharmila RB. Development of in-vehicle noise prediction models for Mumbai Metropolitan Region, India. J Traffic Transp Eng (English Ed.). 2016;3(4):380–7.
[82] Shukla AK, Jain SS, Parida M, Srivastava JB. Performance of FHWA model for predicting traffic noise: A case study of metropolitan city, Lucknow (India). Transport. 2009;24(3):234–40.
[83] Paulo Henrique Trombetta Zannin. Do Nascimento E.; Elaine Carvalho da Paz and Felipe do Valle. Application of Artificial Neural Networks for Noise Barrier Optimization. Environments. 2018;5(12):1–21.
[84] De SK, Swain BK, Goswami S, Das M. Adaptive noise risk modelling: fuzzy logic approach. Syst Sci Control Eng. 2017;5(1):129–41.
[85] Garg N, Mangal SK, Saini PK, Dhiman P, Maji S. Comparison of ANN and Analytical Models in Traffic Noise Modeling and Predictions. Acoust Aust. 2015;43(2):179–89.
[86] de Lisle S. Comparison of Road Traffic Noise Prediction Models: CoRTN, TNM, NMPB, ASJ RTN. Acoust Aust. 2016;44(3):409–13.
[87] Hamad K, Ali Khalil M, Shanableh A. Modeling roadway traffic noise in a hot climate using artificial neural networks. Transp Res Part D Transp Environ. 2017;53:161–77.
[88] Gupta A, Gupta A, Jain K, Gupta S. Noise Pollution and Impact on Children Health. Indian J Pediatr. 2018 Apr;85(4):300–6.
[89] Xie H, Li H, Kang J. The characteristics and control strategies of aircraft noise in China. Appl Acoust. 2014;84:47–57.
[90] Kumar K, Parida M, Katiyar VK. Optimized height of noise barrier for non-urban highway using artificial neural network. Int J Environ Sci Technol. 2014;11(3):719–30.
[91] Liu C, Hornikx M. Effect of water content on noise attenuation over vegetated roofs: results from two field studies. Build Environ. 2018;146(September):1–11.

[92] Singh S, Mohanty AR. HVAC noise control using natural materials to improve vehicle interior sound quality. Appl Acoust. 2018;140(May):100–9.
[93] Vladimir M, Madalina C. Optimizing urban landscapes in regard to noise pollution. Procedia Manuf. 2019;32:161–6.
[94] Bąkowski A, Radziszewski L, Dekýš V, Świetlik P. Frequency analysis of urban traffic noise. 2019 20th International Carpathian Control Conference; 2019 May 26-29; Kraków-Wieliczka, Poland. IEEE, 2019. p. 1–6.
[95] Kim YH, Hwang IH, Hong JY, Lee SC. Effects of vegetation on soundscape of an urban religious precinct: case study of Myeong-dong cathedral in Seoul. Build Environ. 2019;155(March):389–98.
[96] Ow LF, Ghosh S. Urban cities and road traffic noise: reduction through vegetation. Appl Acoust. 2017;120:15–20.
[97] Gil-Lopez T, Medina-Molina M, Verdu-Vazquez A, Martel-Rodriguez B. Acoustic and economic analysis of the use of palm tree pruning waste in noise barriers to mitigate the environmental impact of motorways. Sci Total Environ. 2017 Apr;584-585:1066–76.
[98] Vaitkus A, Čygas D, Vorobjovas V, Andriejauskas T. Traffic/Road Noise Mitigation under Modified Asphalt Pavements. Transp Res Procedia. 2016;14:2698–703.
[99] Cho DS, Mun S. Study to analyze the effects of vehicles and pavement surface types on noise. Appl Acoust. 2008;69(9):833–43.
[100] Liao G, Sakhaeifar MS, Heitzman M, West R, Waller B, Wang S, et al. The effects of pavement surface characteristics on tire/pavement noise. Appl Acoust. 2014;76:14–23.
[101] Jang HS, Kim HJ, Jeon JY. Scale-model method for measuring noise reduction in residential buildings by vegetation. Build Environ. 2015;86:81–8.
[102] Halim H, Abdullah R, Ali AA, Nor MJ. Effectiveness of Existing Noise Barriers: Comparison between Vegetation, Concrete Hollow Block, and Panel Concrete. Procedia Environ Sci. 2015;30:217–21.
[103] Hornikx M, Forssén J. Noise abatement schemes for shielded canyons. Appl Acoust. 2009;70(2):267–83.
[104] Schiff M, Hornikx M, Forssén J. Excess attenuation for sound propagation over an urban canyon. Appl Acoust. 2010;71(6):510–7.
[105] Mazur K, Wrona S, Pawelczyk M. Active noise control for a washing machine. Appl Acoust. 2019;146:89–95.
[106] Padhi T, Chandra M, Kar A, Swamy MN. A new adaptive control strategy for hybrid narrowband active noise control systems in a multi-noise environment. Appl Acoust. 2019;146:355–67.
[107] Jiang J, Li Y. Review of active noise control techniques with emphasis on sound quality enhancement. Appl Acoust. 2018;136(January):139–48.
[108] Peiró-Torres MP, Redondo J, Bravo JM, Pérez JV. Open Noise Barriers Based on Sonic Crystals. Advances in Noise Control in Transport Infrastructures. Transp Res Procedia. 2016;18(June):392–8.
[109] Lacasta AM, Penaranda A, Cantalapiedra IR, Auguet C, Bures S, Urrestarazu M. Acoustic evaluation of modular greenery noise barriers. Urban For Urban Green. 2016;20:172–9.
[110] Wesler JE. Surface Transportation Noise and Its Control. J Air Pollut Control Assoc. 1973;23(8):701–3.
[111] Zambon G, Confalonieri C, Angelini F, Benocci R. Effects of COVID-19 outbreak on the sound environment of the city of Milan, Italy. Noise Mapp. 2021;8(1):116–28.
[112] Manzano JV, Pastor JA, Quesada RG, Aletta F, Oberman T, Mitchell A, et al. The “sound of silence” in Granada during the COVID-19 lockdown. Noise Mapp. 2021 Jan;8(1):16–31.
[113] De Lauro E, Falanga M, Lalli LT. The soundscape of the Trevi fountain in Covid-19 silence. Noise Mapp. 2020 Jan;7(1):212–22.
[114] Spennemann DH, Parker M. Hitting the ‘pause’ button: what does COVID-19 tell us about the future of heritage sounds? Noise Mapp. 2020 Jan;7(1):265–75.
[115] Sakagami K. A note on the acoustic environment in a usually quiet residential area after the “state of emergency” declaration due to COVID-19 pandemic in Japan was lifted: supplementary survey results in post-emergency situations. Noise Mapp. 2020 Jan;7(1):192–8.
[116] Kalawapudi K, Singh T, Vijay R, Goyal N, Kumar R. Effects of COVID-19 pandemic on festival celebrations and noise pollution levels. Noise Mapp. 2021;8(1):89–93.
[117] Mishra A, Das S, Singh D, Maurya AK. Effect of COVID-19 lockdown on noise pollution levels in an Indian city: a case study of Kanpur. Environ Sci Pollut Res Int. 2021 Sep;28(33):46007–19.
[118] Gevú N, Carvalho B, Fagerlande GC, Niemeyer ML, Cortês MM, Torres JC. Rio de Janeiro noise mapping during the COVID-19 pandemic period. Noise Mapp. 2021 Jan;8(1):162–71.
[119] Vasilyev AV. New Methods and Approaches to Acoustic Monitoring and Noise Mapping of Urban Territories and Experience of it Approbation in Conditions of Samara Region of Russia. Procedia Eng. 2017;176:669–74.
[120] Ranpise RB, Tandel BN, Singh VA. Development of traffic noise prediction model for major arterial roads of tier-II city of India (Surat) using artificial neural network. Noise Mapp. 2021;8(1):172–84.
[121] Dąbrowski Z, Stankiewicz B. Methodology of selecting the reference source for an active noise control system in a car. Int J Occup Saf Ergon. 2013;19(1):117–25.
[122] Phan HY, Yano T, Sato T, Nishimura T. Characteristics of road traffic noise in Hanoi and Ho Chi Minh City, Vietnam. Appl Acoust. 2010;71(5):479–85.
[123] Peng J, Liu D, Parnell J, Kessissoglou N. Influence of translational vehicle dynamics on heavy vehicle noise emission. Sci Total Environ. 2019 Nov;689:1358–69.
[124] Pacific Highway pavement grinding trial: Community survey feedback summary. 2020.
[125] SLR Consulting Australia Pty Ltd. Nambucca Heads to Urunga: Low Noise Diamond Grinding Pavement Noise Monitoring. Roads and Maritime Services. 2019.
[126] Jensen P. Control of environmental noise. J Air Pollut Control Assoc. 1973 Dec;23(12):1028–34.
[127] Narang PP. Noise control strategies for occupational safety and better working environments. Int J Occup Saf Ergon. 1995;1(4):311–29.
[128] The Noise Pollution (Regulation and Control) Rules, 2000. Gazette of India; 2000.
[129] Di H, Liu X, Zhang J, Tong Z, Ji M, Li F, et al. Estimation of the quality of an urban acoustic environment based on traffic noise evaluation models. Appl Acoust. 2018;141(June):115–24.