A Comparative Study of Noise Pollution During Dussehra and Diwali Festival in Jabalpur: A Review

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Abstract
Noise pollution has emerged as a significant environmental and public health concern due to rapid urbanization, industrialization, and increased transportation activities. This review thesis critically examines the existing literature on noise pollution, drawing upon studies conducted by various authors to analyze its sources, measurement techniques, impacts, and mitigation strategies. The review highlights major sources of noise pollution, including traffic, industrial operations, construction activities, and urban social environments. Emphasis is placed on the adverse effects of prolonged noise exposure on human health, such as hearing impairment, cardiovascular disorders, sleep disturbance, psychological stress, and reduced quality of life, as reported by previous researchers. Additionally, the review discusses noise assessment methods, standards, and indices commonly employed in environmental studies. Mitigation and control measures proposed by different authors - ranging from urban planning and policy interventions to technological and community-based solutions are also evaluated. By synthesizing findings from diverse studies, this review aims to provide a comprehensive understanding of noise pollution and to identify research gaps that can guide future investigations and effective noise management strategies.

Keywords: Noise pollution, Sound level, Loudspeaker, Navratri, Festival, Diwali, Dussehra Environmental engineering, Jabalpur.

INTRODUCTION

In India, Dussehra and Diwali are two closely linked yet distinct festivals that collectively represent the triumph of good over evil and the transition from conflict to celebration.[4-9] While Dussehra is characterised by large public gatherings, Ramlila performances and the burning of effigies, Diwali involves intensive use of lights, fireworks, and family centred rituals, often leading to different patterns of environmental and social impact.[4-11-5] Noise pollution is recognized as one of the most pervasive forms of environmental pollution, particularly in urban and industrialized regions.[4]Unlike other pollutants, noise is an invisible environmental stressor whose impacts are often underestimated despite being widely experienced. Over the past few decades, rapid urbanization, population growth, industrial expansion, and increased transportation activities have significantly contributed to rising ambient noise levels.[2] As a result, noise pollution has become a growing concern for environmental sustainability and public health, attracting considerable attention from researchers and policymakers worldwide.[22]

Numerous authors have investigated the sources and characteristics of noise pollution, identifying road traffic, railways, airports, industrial machinery, construction activities, and social events as major contributors. [1-3]Studies reported in the literature emphasize that continuous exposure to excessive noise levels can lead to both auditory and non-auditory health effects.[3] According to various researchers, these effects include hearing loss, sleep disturbance, cardiovascular diseases, cognitive impairment, annoyance, and psychological stress. [23] Vulnerable populations such as children, the elderly, and individuals living near high-noise zones are reported to be particularly at risk.[24] Several authors have also focused on methods for measuring and assessing noise pollution, employing parameters such as sound pressure levels, noise indices, and spatial noise mapping techniques. International guidelines and standards proposed by organizations such as the World Health Organization and national regulatory bodies are frequently referenced in the literature to evaluate permissible noise limits.


Fig.1 – Diwali


Fig.2 – Diwali


Fig.3 – Dussehra


Fig.4 - Dussehra

LITERATURE REVIEW

Dussehra and Diwali cause serious noise pollution in Indian cities, but Diwali nights with intense firecracker use usually generate higher and more widespread peak noise levels than Dussehra processions and events. Overall, both festivals routinely exceed Central Pollution Control Board (CPCB) limits in residential, commercial and even silent zones, posing documented health risks.

F. Farcaş et al.: (2012) described this paper "Road traffic noise : GIS tools for mapping and case study for Skane region in southern Sweden"

The author's main objective in this paper is to develop and demonstrate the use of GIS-based tools for mapping and analyzing road traffic noise, using the Skåne region as a case study, so that noise exposure can be evaluated and managed more effectively for urban planning and public health protection. [12]

The author begins by collecting input data such as traffic volume, vehicle composition, speed, and road geometry for the study area, along with basic terrain and building information. Using these inputs, a standard road traffic noise prediction method is applied within a GIS environment to calculate noise levels (e.g., equivalent continuous sound level over a given period) for many points across the network and surrounding area. GIS is used to integrate different spatial data layers (roads, buildings, land use, traffic data) and to run the noise prediction formulas on this spatial database. The calculated noise levels are then visualized as noise maps, which show how noise propagates from roads into adjacent areas, allowing identification of high exposure zones and evaluation of possible mitigation or planning measures. [12] The study showed that using Nordic Prediction Method equations inside GIS makes it possible to compute basic noise levels automatically for every road segment and display them as continuous maps. The resulting maps captured spatial patterns of high and low noise across Skåne, proving that the tools can handle extensive datasets and still provide detailed outputs for planners.[12] Because large area noise maps could be produced efficiently, the authors concluded that such GIS tools are suitable for strategic noise mapping and for supporting decisions on land use planning and mitigation measures.The work also highlighted that existing commercial software at the time was mostly limited to small urban areas, so their approach filled a gap by enabling region wide traffic noise evaluation.

Nitinkumar L. Patel.: (2013) described the “Study of noise pollution during Diwali festival”

The author’s main objective in this study was to measure and analyze the noise levels during the Diwali festival at selected locations, and then compare these measured noise levels with the prescribed standard limits in order to assess the extent of noise pollution. [11] The author identifies several representative locations in the city (e.g., commercial, residential and silent/college or hospital areas) and uses these as fixed noise monitoring stations for the study period. Noise levels are measured on different days related to Diwali (typically a normal day, pre -Diwali day, Diwali day and post -Diwali day) to compare festival noise with the usual background. [11] At each site the author records sound pressure levels with a noise meter and then computes standard indices such as equivalent continuous noise level (Leq), along with minimum and maximum levels over specified time intervals, to quantify and compare exposure.[11] The measured values are compared with prescribed noise limits for different zones to assess the extent of violation, and patterns across locations and days are discussed to highlight the impact of fireworks and festivities on urban noise. [11] The study reports that equivalent noise levels during Diwali exceeded Central Pollution Control Board (CPCB) limits for commercial, residential and silence zones at every monitoring station. Even baseline (non festival) levels in some busy locations were close to or above standards, but festival day values showed a marked additional rise due to firecrackers and related activities. [11] Highest values were observed in commercial or mixed commercial, residential sites with dense traffic and intense cracker use, where average levels reached the upper 70s to 80 dB(A) and peaks were still higher. Silence and residential zones also crossed their much lower limits, indicating that even areas meant to be quiet experienced harmful noise exposure during the festival.[11]

Chittora AK.: (2015) described “of air quality and noise level of Udaipur city, India during Diwali festival

The author’s main objective in this paper was to evaluate how the Diwali festival affected both air quality and noise levels in Udaipur city by comparing pollutant concentrations and sound levels during Diwali with those on normal (pre and post festival) days at selected monitoring locations. [9] The authors selected several monitoring locations in Udaipur representing different land use types (main roads and residential areas) and treated them as fixed stations for measuring both ambient air quality and noise levels around Diwali. Measurements were scheduled on pre -Diwali, Diwali, and post -Diwali days so that festival time values could be compared directly with nearby non -festival days. [9] For air quality, they recorded key pollutants (such as particulate matter and gases) using standard monitoring instruments following environmental guidelines. For noise, they used a sound level meter to capture sound pressure levels in dB(A) over specific time intervals, from which indices like equivalent continuous noise level were derived. The authors compared festival -period pollutant and noise levels with the corresponding non -festival days and with prescribed national standards to judge the extent of deterioration in environmental quality. They interpreted spatial and temporal patterns (which locations and which festival days or times were worst) to highlight how Diwali fireworks and associated activities impact Udaipur’s air quality and noise environment. [9]

The study found that concentrations of major air pollutants such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), suspended particulate matter (SPM) and respirable suspended particulate matter (RSPM) were all higher on the Diwali day than on the non- festival day at both commercial and residential monitoring sites. These elevated values exceeded Indian National Ambient Air Quality Standards, indicating short -term but serious degradation of air quality due to fireworks. [9] Night-time noise levels measured between 18:00 and 06:00 during Diwali far exceeded the prescribed limits of 55 dB (day) and 45 dB (night) for residential areas, making the acoustic environment "unbearable" at both the commercial and residential sites. The authors link this excess noise mainly to the intensive use of firecrackers and associated festival activities, concluding that Diwali transforms an otherwise cleaner environment into one with hazardous noise exposure. [9] The paper emphasizes that the combination of high particulate pollution and extreme noise during Diwali poses significant risks such as respiratory problems, irritation, hearing effects, and stress among residents. On this basis, the authors recommend urgent control measures on firecracker use and stricter enforcement of noise and air -quality regulations during the festival in Udaipur. [9]

Ajay Vikram Ahirwar.: (2015) described "Assesment of noise pollution during Deepawali festival in Raipur city of Chhattishgarh, India".

The main objective of this paper is to assess and compare the noise pollution levels during the Deepawali festival at different types of locations (such as residential and commercial areas) in Raipur city, Chhattisgarh, and to evaluate how these measured levels relate to the prescribed noise standards so that the extent of noise pollution and its potential impact on the urban environment can be understood.[8] The authors selected multiple locations in Raipur (such as residential, commercial and silence zones) and measured ambient noise levels there before, during and after the Deepawali festival to capture the impact of firecrackers and celebrations. At each site they recorded standard acoustic parameters like equivalent continuous sound level (Leq) over defined time intervals, following CPCB/IS guidelines for noise monitoring. [8] Measurements were taken using a calibrated sound level meter positioned at specified heights and distances from major noise sources, generally during evening and night hours when firecracker use peaks. The authors then compared recorded levels with national ambient noise standards for different land-use categories and evaluated how much festival-period noise exceeded these limits. [8] The approach emphasized quantifying both spatial variation (between residential, commercial, silence areas) and temporal variation (pre -festival v/s festival day v/s post -festival) to assess the extent of noise pollution attributable specifically to Deepawali activities. From these comparisons they inferred health and environmental implications and suggested regulatory and awareness measures for noise control during festivals. [8] Average equivalent noise levels during the Deepawali period were about 81 dB in commercial areas, 68 dB in residential areas and 66 dB in silence zones, all above the respective national standards for day or night time. This demonstrated that even silence and residential zones experienced noise far beyond acceptable limits, mainly due to firecrackers and traffic during the festival. [8]

The study observed that the highest average noise generally occurred on Deepawali day (especially at night) and around busy commercial locations, where levels reached up to about 96 dB. Noise remained elevated compared with normal days even before and after the festival, showing a wider temporal impact rather than a single -day spike.

From these results, the authors concluded that Deepawali activities substantially deteriorate the acoustic environment of Raipur and pose potential risks to public health and well-being. They emphasized the need for stricter enforcement of noise regulations and public awareness campaigns to control festival -related noise pollution.

Rakesh Dubey.: (2021) described "GIS mapping of short – term noisy event of Diwali night in

Lucknow city”
The objective of this paper was to map and analyze short - term noise levels during Diwali night in Lucknow City using GIS, in order to identify spatial patterns of noisy areas and assess how firecracker -related activities affect the urban acoustic environment. [5] The authors conducted short-term noise measurements at multiple locations across Lucknow during Diwali night using sound level meters (e.g., recording equivalent continuous sound level, Leq). They selected sites representing different land uses (residential, commercial, mixed, and sensitive zones) to capture spatial variation in festival noise. The point noise data were geo-referenced and imported into a GIS environment with the city’s base maps and land- use layers. Interpolation techniques (such as Inverse Distance Weighting) were applied to generate continuous noise surfaces showing how sound levels varied across the urban area. [5] The mapped noise levels were compared with national ambient noise standards to identify exceedance zones and intensity classes. The authors then interpreted spatial patterns (hotspots, high -risk areas near sensitive land uses) to discuss implications for urban planning and festival noise management. [5] The study reported that equivalent noise levels during Diwali night were substantially higher than the prescribed limits for residential, commercial and silence areas, showing widespread non-compliance with CPCB norms. The mapped noise surfaces highlighted that even traditionally quieter or sensitive zones experienced levels above allowable thresholds during the festival period. [5] GIS interpolation revealed clustered areas of extreme noise, especially in dense commercial and mixed -use parts of the city where firecracker use and traffic were intense. These spatial patterns demonstrated that noise pollution during Diwali is not uniform but concentrated in specific urban pockets, providing evidence for targeted control and awareness measures. [5]

Sourav Kumar Bhoiet al.: (2022) described "Analysis of Noise Pollution during Dussehra Festival in Bhubaneswar Smart City in India, A Study Using Machine Intelligence Models"
The objective of the authors in this paper is to analyze and predict noise pollution levels during the Dussehra festival in Bhubaneswar Smart City using machine- intelligence (machine learning) models, based on noise data collected at different locations and times.[4] The authors first selected multiple monitoring locations within Bhubaneswar Smart City representing residential, commercial, traffic and mixed land- use zones, and then measured noise levels during the Dussehra festival using a calibrated sound level meter over specified time slots (day, evening, night) for several days including a normal (non festival) reference period. From these measurements they computed standard acoustic indicators such as equivalent continuous sound level (Leq) and compared them against regulatory limits for each land-use category. [4] After preparing the dataset (noise levels plus explanatory variables like location type, time period, traffic/festival activity), the authors trained machine learning models (e.g., regression or classification models) to analyze patterns and to predict noise levels at different locations and times during the festival. Model performance was then evaluated using common statistical/error metrics, and the best performing model was used to interpret which factors most strongly influenced festival noise levels. [4] The authors finally interpreted the model outputs to identify hotspots, temporal peaks (such as evenings of immersion or main processions), and the degree of exceedance over prescribed limits in each zone. On this basis they suggested policy and management measures for municipal and regulatory authorities, such as stricter control on loudspeakers/firecrackers in sensitive areas and better planning of processions to mitigate noise during future Dussehra celebrations. [4] Among all the tested supervised ML algorithms (DT, NN, k- NN, NB, SVM, RF), Decision Tree and Random Forest achieved the best classification accuracy of about 92.5% for predicting whether noise levels are high or low relative to the

standard limits. [4] Decision Tree was more effective for correctly predicting high- noise cases, whereas Random Forest performed better for low- noise cases in the test data. [4] Using multi-year data (2015–2020) from different zones (silence, industrial, commercial, residential), the study shows that during Dussehra 2020, many observations fall in the high -noise category compared to regulatory thresholds, indicating significant festival-related noise pollution risk in the smart city. [4] The authors therefore highlight that regular monitoring combined with ML -based prediction is a practical tool for city authorities to anticipate exceedances and plan control measures during festivals. [4]

Rajeev Ranjan et al.: (2023) described "Monitoring of traffic noise pollution in urban Patna, Bihar, India,"

The main objective of this paper is to systematically measure and evaluate traffic noise levels at different urban locations in Patna, Bihar, and compare the observed noise with national and international standard limits in order to assess the extent of noise pollution and its potential impact on residents.[3] A preliminary traffic volume survey was conducted to identify representative and busy roadside locations, after which 12 monitoring stations were chosen in different urban land use zones of Patna. [3] At each station, A weighted sound pressure levels were recorded using a sound level meter during specified periods, generating continuous datasets from which statistical noise levels such as L10, L50 and L90 obtained. The authors computed key traffic noise indices - Equivalent Continuous Noise Level (Leq), Noise Climate (NC), Noise Pollution Level (NPL) and Traffic Noise Index (TNI) from the measured L10, L50, L90 values for each site. These indices were then compared with the prescribed limits of the Central Pollution Control Board (CPCB) for the relevant zone types to evaluate the extent to which traffic noise exceeded regulatory standards. [3] Correlation analysis was performed among Leq, NPL, TNI and NC to understand relationships between different descriptors and to identify which indices best represented overall traffic noise pollution. [3] A regression model was developed using NPL as the dependent variable and TNI, NC and Leq as predictors, and this model was statistically validated to check its suitability for describing traffic noise conditions in Patna. [3] The equivalent continuous noise level Leq in the commercial, residential locations ranged roughly from about 78 to 93 dB(A), clearly higher than the relevant CPCB standards for those zones. [3] Other indices such as Noise Pollution Level (NPL) and Traffic Noise Index (TNI) were also consistently above recommended limits, confirming that residents are exposed to unacceptable traffic noise throughout the study area. The study reported strong positive correlations between NPL and both TNI and Noise Climate (NC), and also between Leq and NPL (correlation coefficient greater than 0.5), showing that these indices move together and can reliably describe the noise environment. [3] A regression model using NPL as the dependent variable and TNI, NC and Leq as predictors was successfully validated, suggesting that traffic noise conditions in Patna can be effectively represented and predicted using these combined indices. [3]

Shashi Kant Tiwari et al.: (2024) described "Traffic noise measurement, mapping, and modeling using soft computing techniques for mid-sized smart Indian city"

The objective of the authors in this paper was to "measure, map, and model urban traffic noise for a mid-sized Indian smart city using soft computing techniques", so that they could better understand current noise levels and develop predictive tools for managing and controlling traffic noise in the city's planning and policy.[1] They measured traffic noise indices (such as Leq and L10) at multiple locations in Dhanbad using a calibrated sound level meter, following relevant standards over several months and different time intervals. Along with sound levels, they recorded traffic and road variables including counts of different vehicle types, traffic speed, and related influencing factors needed for modeling. [1]

Using the measured Leq values at each site, they generated spatial noise maps in Arc GIS to visualize how traffic noise varied across the city at different times of day. Interpolation techniques were applied to estimate noise levels between monitoring points, highlighting hotspots where noise exceeded acceptable limits. [1] They developed two predictive models: a Multiple Linear Regression (MLR) model and an Artificial Neural Network (ANN) model, both using traffic and road parameters as inputs to estimate Leq and L10. Model performance was evaluated with metrics such as coefficient of determination R^2 and RMSE, showing that the ANN model predicted traffic noise indices more accurately than the MLR model. [1] Frequency spectrum analysis was conducted to identify dominant frequency bands in the traffic noise, with notable peaks in low, mid, and high frequency ranges. The combined ANN based prediction and GIS noise mapping framework was proposed as a decision support tool for planning noise mitigation strategies in mid-sized smart cities like Dhanbad. [1] The ANN achieved very high goodness of fit for predicting Leq and L10 (coefficients of determination around 0.94 and 0.91, respectively), with substantially lower RMSE values than the MLR model. This showed that traffic noise generation in the mixed-traffic conditions of a mid-sized Indian city is highly nonlinear and better captured by ANN-based soft computing than by linear regression. [1] Noise maps generated from field measurements indicated that many road sections in Dhanbad experience traffic noise above recommended limits during several time intervals, reflecting intense vehicular movement. Frequency analysis revealed dominant energy at low (31.5–50 Hz), mid (500–800 Hz), and high (3.5–5 kHz) bands, emphasizing that a wide spectral range contributes to urban traffic noise exposure. [1] The study concludes that an ANN-based prediction framework, integrated with GIS noise mapping, can serve as a practical tool for smart-city planners to anticipate traffic noise hotspots and design targeted mitigation strategies.

Domenico Rossi et al.: (2024) described "Coupling Different Road Traffic Noise Models with a Multi linear Regressive Model: A Measurements-Independent Technique for Urban Road Traffic Noise Prediction"

The authors aimed to couple several existing road traffic noise emission models with a sound propagation model, generate a synthetic dataset of traffic conditions, and then fit a multi-linear regression model that provides simple formulas for estimating equivalent continuous sound levels. Their goal was to make road traffic noise models easier to apply in different urban contexts, so that noise levels can be forecast using data from traffic sensors alone, rather than expensive and time consuming sound level measurements. [2] They selected different established road traffic noise models (each using variables such as traffic flow, heavy vehicle share, speed, and road geometry) and mathematically coupled them so that all relevant explanatory variables could be used together in a single predictive structure. [2] This coupling allowed them to exploit the strengths of each original model while reducing individual model weaknesses, aiming for better prediction accuracy across varied urban scenarios. [2] Using simulated outputs from the coupled models as inputs, they built a multi-linear regression model where noise level is expressed as a linear combination of traffic and infrastructure variables, with regression coefficients estimated statistically. [2] They validated this regression model against reference situations and showed that it can estimate road traffic noise levels reliably without requiring direct sound pressure measurements at each site, making it "measurement independent" for urban planning applications. [2] The regression based formulas derived from the coupled models produced mean absolute errors of roughly 1.6–2.6 dB(A) when compared with long term monitored noise data at an urban road site. [2] This error range shows that the simplified equations can reproduce observed equivalent continuous sound levels with good reliability for practical applications. [2] Because the model is calibrated using simulated data from standard noise emission models rather than local sound measurements, it can be deployed in different urban contexts without repeating expensive acoustic campaigns. [2] The authors therefore conclude that these multi-linear regression formulas can be embedded into traffic sensor networks or planning tools to forecast noise levels over road networks in a computationally efficient way. [2]

HEALTH EFFECTS FROM NOISE

Noise pollution during Dussehra and Diwali festivals in India exceeds permissible limits, Environmental noise pollution leads to a wide range of auditory, cardiovascular, sleep, mental, and cognitive health effects, and these risks are highly relevant for festival-related noise from firecrackers and loudspeakers.[1-24]

1. Auditory health effects - Continuous exposure above about 75–80 dB can cause permanent sensorineural hearing loss, especially when levels exceed 85 dB for many hours or repeated days. Firecrackers and loudspeakers during festivals can easily produce peaks above 120 dB, leading to noise-induced hearing loss (NIHL), tinnitus, abnormal loudness perception, and distorted hearing (paracusis) NIHL is typically bilateral, irreversible, and progresses with repeated exposure; damage involves cochlear hair cells, supporting cells, and cochlear blood flow changes driven by oxidative stress and inflammation.[5-6-21-25]
2. Cardiovascular and metabolic effects - Environmental noise is recognized as a major environmental risk factor, contributing to hypertension, ischemic heart disease, myocardial infarction, and stroke through chronic stress-pathway activation.[21] Short-term exposure can temporarily raise blood pressure and blood viscosity, while long-term exposure is associated with higher rates of cardiovascular disease and type 2 diabetes, likely via elevated stress hormones and autonomic imbalance.[25]
3. Sleep disturbance and annoyance - Uninterrupted sleep is known to be a prerequisite for good physiologic and mental functioning in healthy individuals. Environmental noise is one of the major causes of disturbed sleep. When sleep disruption becomes chronic, the results are mood changes, decrements in performance, and other long-term effects on health and well-being. Much recent research has focused on noise from aircraft, roadways, and trains. It is known, for example, that continuous noise in excess of 30 dB disturbs sleep.[25-23]
4. Mental effects - Chronic noise exposure is associated with increased stress, anxiety, depression, mood swings, and reduced overall well-being, reflecting its role as a constant environmental stressor.[24] In children, high noise levels are linked to impaired memory, attention deficits, reading delays, and poorer school performance, especially when schools or homes are near busy roads or other major sources.[23] Emerging evidence suggests possible links between long-term noise exposure and cognitive decline and dementia, though mechanisms are still being investigated.

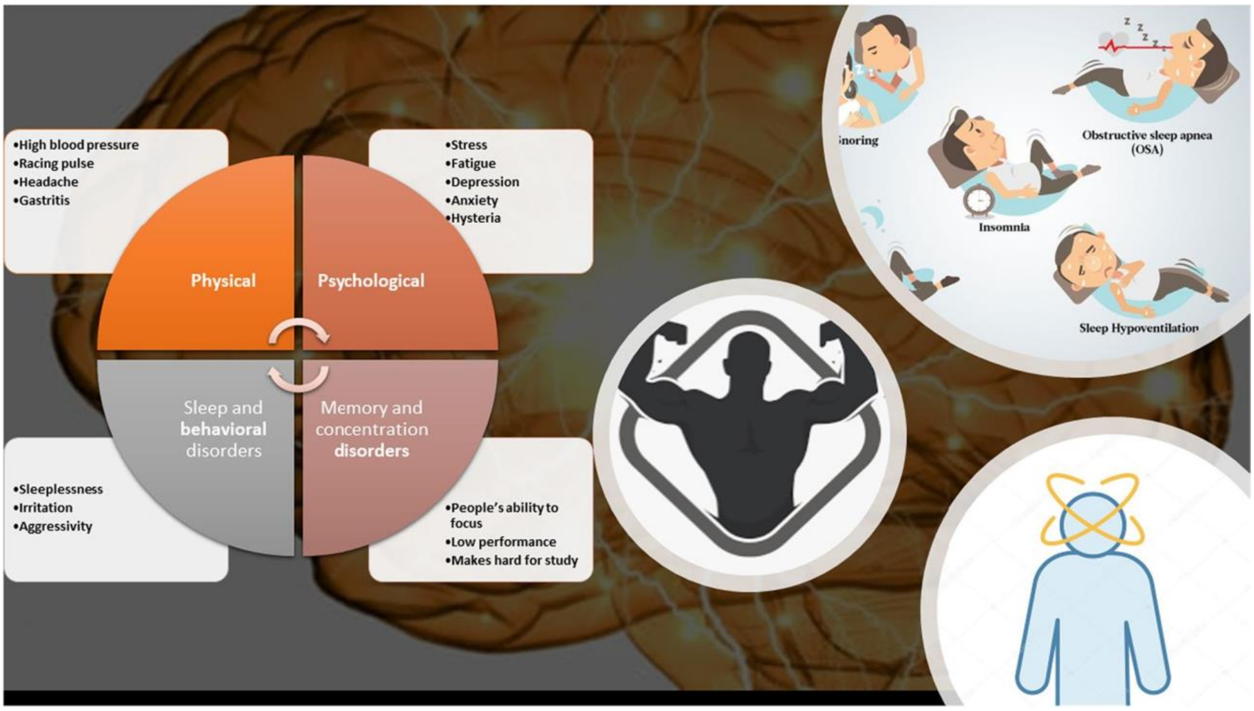

Fig.5 - Health effects of noise

CONCLUSION

The consistently indicate that noise pollution is primarily driven by rapid urbanization, increased transportation, industrial activities, and unplanned urban development. Across different geographical regions, authors have reported that ambient noise levels in many urban areas frequently exceed recommended national and international standards. The literature clearly demonstrates that prolonged exposure to high noise levels has detrimental effects on human health and well-being. Authors have documented both auditory effects, such as temporary and permanent hearing loss, and non-auditory effects, including sleep disturbance, cardiovascular disorders, reduced cognitive performance, annoyance, and psychological stress. These impacts emphasize that noise pollution is not merely a nuisance but a serious environmental risk factor requiring urgent attention. Research reviewed also reveals a wide range of noise assessment methods and indicators used by authors to evaluate noise levels and exposure. While these methods provide valuable insights, variations in measurement techniques and study designs make direct comparisons challenging. Nevertheless, the use of standardized guidelines and noise mapping approaches has been recognized as an effective tool for understanding spatial noise distribution and exposure patterns. In conclusion, this review underscores the need for strengthened policy frameworks, improved urban planning, and continued research to address noise pollution effectively.

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