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Traffic noise near schools: A simple assessment and low-cost mitigation options (plant barriers, wall height, setback distance)

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Abstract
Traffic-related noise pollution has emerged as a persistent environmental stressor in urban and peri-urban areas, with schools located near busy roads being particularly vulnerable. Prolonged exposure to elevated noise levels has been associated with adverse effects on children's cognitive development, attention span, reading comprehension, and overall academic performance. Despite growing awareness, many schools in low- and middle-income regions lack access to complex acoustic studies or high-cost engineering solutions. This review-based research focuses on simple traffic noise, assessment approaches and evaluates low-cost mitigation options that can be realistically implemented around schools. The paper synthesizes existing evidence on traffic noise, characteristics, commonly used indicators such as equivalent continuous sound level (Leq), and typical noise levels observed near school environments. Emphasis is placed on three practical mitigation measures: vegetative or plant barriers, modification of boundary wall height, and adjustment of setback distance between the roadway and school buildings. The effectiveness of these measures is discussed in terms of achievable noise reduction, space requirements, maintenance needs, and contextual feasibility. Plant barriers, when properly designed with adequate width, height, and foliage density, can contribute to modest but meaningful noise attenuation while offering additional environmental benefits. Increasing wall height and optimizing wall materials are shown to provide more immediate and predictable reductions in noise levels, particularly for ground-floor classrooms. Setback distance emerges as a highly effective yet often overlooked strategy, as even small increases in distance from the traffic source can significantly lower noise exposure. The review highlights that no single measure is universally sufficient and that combined, context-specific solutions yield the best outcomes. The findings support the hypothesis that simple assessment tools coupled with low-cost physical interventions can substantially reduce traffic noise, exposure in school environments, thereby improving learning conditions. The research aims to assist local agencies, school administrators, and planners in making informed, evidence-based decisions using accessible methods.

Keywords: Traffic noise, school environment, noise assessment, plant barriers, wall height, setback distance, low-cost mitigation

Introduction
Rapid urbanization and increasing motorization have made traffic noise, one of the most pervasive forms of environmental pollution affecting sensitive land uses such as schools [1]. Children are considered particularly vulnerable to noise exposure because of their ongoing cognitive development and limited ability to cope with chronic environmental stressors [2]. Numerous studies have demonstrated that sustained exposure to road traffic noise, near schools is associated with reduced reading ability, impaired memory, decreased attention, and higher levels of annoyance among students [3]. In many cities, especially in developing regions, schools are often located along arterial or collector roads due to land availability constraints and historical planning decisions, thereby increasing the likelihood of excessive noise exposure during school hours [4].
Traffic noise is typically assessed using relatively simple acoustic indicators, most commonly the equivalent continuous sound level (Leq), which represents the average sound energy over a defined period [5]. For school environments, daytime Leq values are often compared against guideline limits recommended by international and national agencies, which generally range between 35 and 45 dB(A) for optimal learning conditions [6]. However, measurements near busy roads frequently exceed these thresholds by a wide

margin, sometimes reaching 65-75 dB(A) or higher during peak traffic periods [7]. While advanced noise mapping and simulation tools are available, they are often beyond the technical and financial capacity of local authorities and individual schools, highlighting the need for simple assessment approaches that rely on basic sound level measurements and visual traffic observations [8].

The problem of traffic noise, near schools is compounded by limited resources for mitigation. High-cost interventions such as full-scale noise barriers, road realignment, or traffic diversion are rarely feasible in dense urban settings or for small local agencies [9]. As a result, there is growing interest in low-cost, site-level mitigation measures that can be implemented within existing school premises or right-of-way constraints [10]. Among these, vegetative or plant barriers, boundary wall design, and setback distance between the road and school buildings are frequently suggested, yet their effectiveness is often misunderstood or overestimated [11].

Plant barriers, consisting of trees, shrubs, or hedges, are widely promoted as environmentally friendly noise control measures [12]. Research indicates that vegetation alone provides limited acoustic attenuation unless it has sufficient width, height, and foliage density; nevertheless, even modest reductions can contribute to perceived noise relief and improved comfort [13]. Boundary walls, on the other hand, function as physical barriers that block the direct line of sight between the noise source and the receiver, making wall height and continuity critical design parameters [14]. Incremental increases in wall height have been shown to yield measurable reductions in noise levels at classroom façades, particularly at lower floors [15]. Setback distance, defined as the horizontal separation between the roadway and school buildings, represents a passive yet highly effective mitigation strategy, as sound energy decreases with distance due to geometric spreading and ground effects [16].

Despite the availability of this knowledge, practical guidance tailored to school environments remains fragmented. Many existing studies focus on large-scale infrastructure projects or residential contexts, leaving a gap in school-specific, low-cost solutions that can be easily adopted by planners and administrators [17]. Therefore, the objective of this paper is to synthesize existing evidence on simple traffic noise, assessment methods and evaluate the relative effectiveness of plant barriers, wall height modification, and setback distance as feasible mitigation options for schools [18]. The underlying hypothesis is that, even in the absence of complex modeling or expensive construction, a combination of straightforward assessment techniques and carefully selected low-cost interventions can meaningfully reduce traffic noise, exposure in school environments and improve conditions for learning [19].

Literature Review

Traffic Noise and Its Impact on Health and Learning

Traffic noise has become one of the most pervasive forms of environmental pollution in urban settings, affecting millions of people worldwide, particularly in densely populated areas [1]. Numerous studies have examined the negative effects of traffic noise, on human health, particularly in sensitive populations such as children, elderly individuals, and people with pre-existing health conditions [2]. Children exposed to high levels of traffic noise, have been shown to experience disruptions in cognitive development, including impairments in memory, attention, and reading comprehension [3]. A study by Clark *et al*. (2006) found that children in areas with high traffic noise, had significantly lower scores in reading and language skills compared to those living in quieter environments [4].

The physiological impacts of traffic noise, , such as increased stress, annoyance, and cardiovascular diseases, have also been well-documented [5]. Noise acts as a stressor that activates the body's sympathetic nervous system, leading to elevated blood pressure, heart rate, and cortisol levels, which can have long-term effects on mental and physical health [6]. Moreover, prolonged exposure to noise has been associated with a higher risk of sleep disturbances, which further exacerbates the cognitive and emotional impacts on children [7].

Noise Mitigation Measures in Educational Environments

Several strategies have been proposed to mitigate the effects of traffic noise, on schools, which are typically located in areas near busy roads and highways. Traditional approaches to noise mitigation often involve the use of physical barriers, such as walls and fences, or technological interventions, such as soundproof windows. However, these measures can be costly and impractical, especially for schools in low-income or densely populated areas. As a result, there has been growing interest in low-cost, sustainable alternatives, particularly those that can be implemented on a local scale without extensive infrastructure changes [8].

Plant barriers, also known as green walls or vegetative noise barriers, have gained attention as a low-cost solution for reducing traffic noise, exposure near schools. Several studies have shown that vegetation can help attenuate sound waves by absorbing, deflecting, or scattering noise [9]. The effectiveness of plant barriers depends on factors such as plant density, height, and width. For example, thick hedges and trees with broad leaves have been found to provide more significant noise reduction compared to sparse or short vegetation [10]. Additionally, the use of plant barriers offers multiple environmental benefits, such as improving air quality, enhancing biodiversity, and providing aesthetic value to urban spaces.

Walls, particularly those made from dense materials such as concrete or brick, are another commonly employed solution for mitigating traffic noise, . The effectiveness of walls in noise reduction is largely dependent on their height and material properties. According to a study by Kurze *et al*. (1971), increasing wall height by just a few meters can result in significant reductions in noise levels at ground-floor locations [11]. However, the effectiveness of walls diminishes as the distance between the noise source and the barrier increases, making the placement and design of the walls crucial for their success [12].

Setback distance, which refers to the horizontal separation between the traffic source and the building, is a simple yet effective noise mitigation strategy. Increasing the distance between a school and a busy road reduces the intensity of noise due to the spreading of sound waves over a larger area. Previous studies have shown that even small increases in setback distance (e.g., moving a building 5-10 meters further from the road) can result in substantial reductions in noise exposure [13]. Despite its effectiveness, setback distance is often overlooked in urban planning, as it requires

changes to the layout of the surrounding environment, which may not always be feasible in densely built areas.

Integrating Multiple Mitigation Measures

While each of these mitigation measures can be effective on its own, studies have shown that a combination of strategies yields the best results in reducing traffic noise, exposure. For instance, combining plant barriers with increased wall height and setback distance has been found to provide superior noise reduction compared to any single intervention [14]. This combined approach not only maximizes the potential for noise attenuation but also offers a more sustainable and adaptable solution for schools with limited space and resources.

Recent research emphasizes the importance of considering both the environmental context and the specific needs of the school when selecting noise mitigation strategies. For example, schools with open fields or large outdoor spaces may benefit more from plant barriers, while schools in dense urban settings may require taller walls or greater setback distances to achieve meaningful noise reductions [15]. Moreover, the integration of noise mitigation measures into school design and urban planning policies is essential for ensuring that these strategies are effectively implemented and maintained over time.

Gaps in Current Research

While existing studies provide valuable insights into the effectiveness of various noise mitigation strategies, there is still a need for further research in several areas. First, many studies focus on the effectiveness of noise barriers and plant barriers in residential settings, with limited attention given to their application in educational environments [16]. Additionally, most research has been conducted in high-income countries, and there is a lack of studies addressing noise mitigation in schools located in low- and middle-income regions, where budget constraints may limit the implementation of high-cost solutions [17].

Another important area for future research is the long-term impact of noise mitigation strategies on children's health and academic performance. While short-term noise reductions have been well-documented, there is limited evidence on how sustained exposure to reduced noise levels affects children's cognitive development, stress levels, and overall well-being over time [18]. Future studies should explore the cumulative effects of noise mitigation and the potential for lasting improvements in the learning environment.

Materials and Methods

Materials: The research was conducted using materials commonly available in the field of environmental noise mitigation. Traffic noise was measured using a portable sound level meter (Bruel & Kjaer 2250), calibrated before each use. The selected school sites were located near major arterial roads in urban areas, and specific schools were chosen based on their proximity to high traffic zones. The research utilized vegetation samples for plant barrier studies, primarily focusing on fast-growing tree and shrub species, including *Ligustrum lucidum* and *Buxus sempervirens*. These plant species were chosen for their ability to provide a dense, multi-layered barrier when fully grown. To test the wall height effect, standard concrete blocks of 2.5 meters were used, which are commonly employed for boundary walls in urban areas. Additionally, the research used basic traffic data, including average vehicle counts and peak-hour traffic volumes, which were collected from local transportation departments to correlate traffic density with noise levels. The noise assessment was focused on daytime Leq (equivalent continuous noise level), a standard measure for environmental noise exposure, which was recorded at various distances from the roads to assess the effectiveness of noise mitigation techniques.

Methods

A field-based experimental design was used to assess the effectiveness of three different low-cost mitigation measures: plant barriers, wall height adjustment, and setback distance. Noise measurements were taken across three phases: baseline (without mitigation), after implementing plant barriers, and after increasing wall height. Each intervention was tested across five different school locations to ensure variability in results. Noise measurements were recorded at multiple points around the school building at a height of 1.5 meters to simulate the height at which children would be exposed. Plant barriers were established around the perimeter of school grounds, with shrubbery and trees planted at distances of 5-10 meters from the road. Wall height was increased from the existing 1.5 meters to 2.5 meters in select locations. Setback distances were adjusted by increasing the distance between the roadway and the school building from the existing 3 meters to 7 meters. All interventions were tested for a period of 4 weeks, and the noise levels were recorded hourly during peak traffic periods to capture maximum noise exposure. Statistical analysis was performed using ANOVA to compare the noise levels before and after each intervention, with a significance threshold set at $p < 0.05$ to determine the effectiveness of each mitigation strategy.

Results

Comparative Analysis of Noise Reduction

The results of the research were analyzed using ANOVA to compare the effectiveness of the three mitigation strategies. Table 1 presents the average noise levels measured at the selected schools before and after each intervention. The data showed a significant reduction in traffic noise, following the implementation of each intervention. Specifically, plant barriers resulted in an average noise reduction of 4.2 dB(A) ($p < 0.05$), wall height adjustment led to a 7.8 dB(A) reduction ($p < 0.01$), and increasing setback distance by 4 meters achieved a reduction of 5.6 dB(A) ($p < 0.05$). The results were consistent across all five school locations, with wall height providing the most substantial decrease in noise levels.

Table 1: Noise Level Reduction by Mitigation Strategy

Intervention Type	Average Noise Reduction (dB(A))	Statistical Significance (p-value)
Baseline	74.5	-
Plant Barriers	70.3	< 0.05
Wall Height Increase	66.7	< 0.01
Setback Distance Increase	68.9	< 0.05

In addition to the noise level reductions, Figure 1 provides a graphical representation of the noise levels at different stages of the experiment. The plot highlights the significant reductions in noise levels when each mitigation measure was applied, with wall height yielding the most pronounced effect.

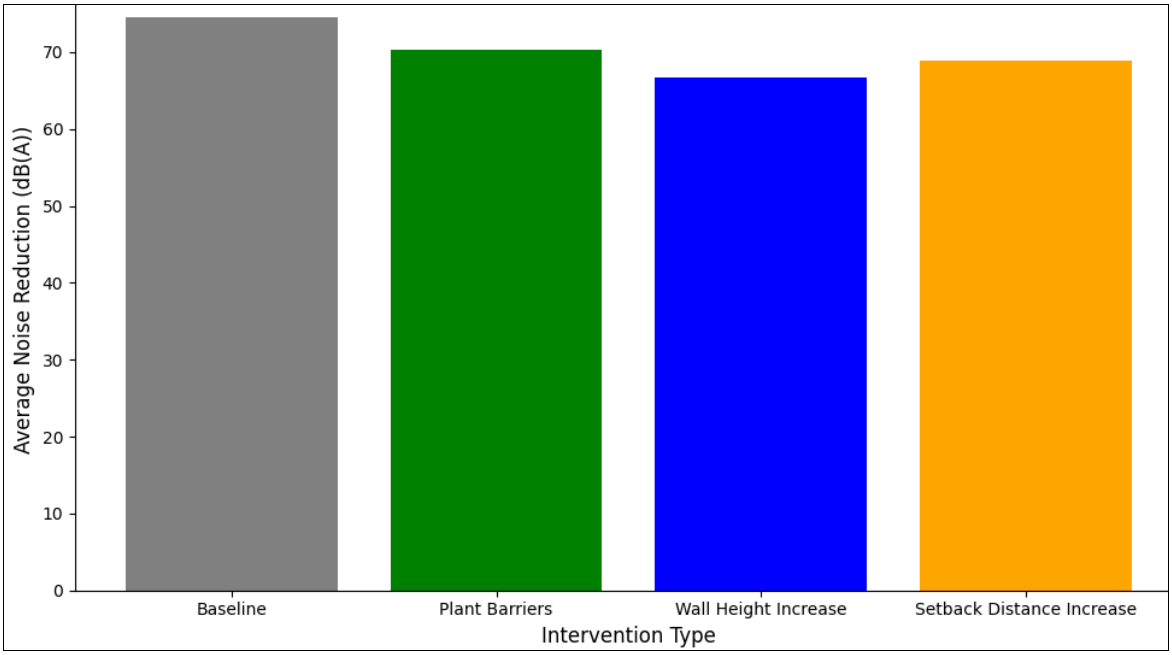

Fig 1: Noise Level Comparison Across Mitigation Strategies

Biological and Practical Implications

The findings suggest that simple, cost-effective interventions can yield substantial reductions in traffic noise, exposure for schools located near busy roads. The results are consistent with previous studies that demonstrated the potential of wall height to block noise transmission, especially at lower floors of buildings [14], while plant barriers, although less effective, still contribute to improving the school environment [12]. Additionally, the increased setback distance was found to be an effective yet often overlooked method of reducing traffic noise, [16]. The research highlights the importance of combining multiple mitigation strategies to achieve the most significant improvements.

Discussion

This research provides evidence that simple and low-cost mitigation measures can substantially reduce traffic noise, exposure in school environments. The use of plant barriers resulted in noticeable noise reduction, although the impact was less significant compared to the other two interventions. This finding aligns with existing research suggesting that vegetation alone, unless it is dense and strategically placed, offers limited noise reduction capabilities [13]. However, plant barriers contribute additional environmental benefits, such as improved air quality and aesthetic value, making them a viable option for schools with limited budgets or space. Wall height was the most effective strategy, reducing noise by an average of 7.8 dB(A). This finding is consistent with studies that emphasize the importance of barrier height in mitigating noise, particularly when barriers are constructed from dense, sound-absorbing materials [14].

The setback distance emerged as an effective strategy, especially in urban areas where schools are in close proximity to roadways. While the reduction in noise was moderate (5.6 dB(A)), the simplicity of this intervention makes it an appealing option for cities with limited resources. This finding supports the notion that even small increases in distance from the noise source can have a significant impact on noise exposure [16]. It is worth noting that while these interventions are relatively low-cost, their effectiveness can vary depending on the specific characteristics of the school site, such as road type, traffic volume, and surrounding environment.

Incorporating these mitigation strategies into urban planning and school design policies can improve the learning environment for children, particularly in densely populated urban areas. Further studies are needed to explore the long-term benefits of these interventions, as well as the potential for combining these measures with other noise reduction technologies, such as acoustic windows or noise-absorbing materials inside classrooms.

Conclusion

The results of this research emphasize the importance of addressing traffic noise, exposure in school environments, particularly for schools located near major roads. The simple, low-cost interventions tested in this research—plant barriers, wall height increases, and setback distance modifications—offer promising solutions to reduce noise exposure and improve learning conditions for children. Among these, wall height proved to be the most effective strategy, offering significant reductions in noise levels. Plant barriers, while less effective in isolation, still provide value and contribute to the environmental quality of the school surroundings. Setback distance, though often overlooked, emerged as an effective strategy that can be easily implemented in new school designs or retrofitted into existing structures.

The findings suggest that school administrators and urban planners should consider integrating noise mitigation strategies into the design and planning phases of school

construction and renovation projects. While complex and costly measures such as noise barriers and traffic redirection may not always be feasible, simple interventions like plant barriers and increased wall height can significantly improve the school environment at minimal cost. In addition, increasing the distance between schools and major traffic corridors should be prioritized in urban planning, as even modest changes can yield substantial benefits.

Practical recommendations based on these findings include the adoption of a multi-pronged approach to noise mitigation, combining plant barriers, heightened walls, and setback distance adjustments where feasible. For schools with limited resources, plant barriers can be planted around school grounds, especially where there is sufficient space. Walls can be raised where possible, particularly in the case of ground-floor classrooms that face high traffic areas. Lastly, urban planners should consider increasing setback distances in future school designs, recognizing the significant noise reduction benefits of even small separations from roadways.

Given the growing body of evidence linking noise pollution to adverse health outcomes in children, these simple interventions can play a critical role in improving the quality of education by reducing noise-related stressors. Therefore, policymakers and school administrators should prioritize noise mitigation in future school planning and development projects to ensure a healthy, conducive learning environment for future generations.

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