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Review article

Understanding environmental noise: Transmission, attenuation, resonance and health implications ☆

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ABSTRACT

This paper investigates the behavior of environmental noise, a critical topic for acoustic experts. Sound and noise propagate through various media via pressure variations, with attenuation significantly influenced by environmental factors, source types, frequencies, and climatic conditions. Attenuation refers to the reduction of sound intensity. Noise sources are classified into point, line, and plane categories. Sound is perceived by the human ear, while noise is unwanted sound. The distinction between the two depends on individual perception, the environment, and circumstances. Noise can be audible or inaudible, with inaudible noise, such as infrasound and ultrasound, potentially posing health risks. This paper examines noise attenuation in relation to sources, frequencies, and site conditions such as resonance phenomena. It also addresses the limitations of current acoustic measurement technologies and proposes advancements for the field of acoustic science due to neglecting resonance phenomena. By understanding these factors, we can effectively assess and mitigate the impact of noise on human and animal health and the environment.

What is known: Sound and noise propagate through pressure variations in air, liquid, or solid. Noise sources are categorized into point, line, and plane sources. While sound is what we hear, noise is considered unwanted sound. The reduction of sound intensity, known as attenuation, varies based on environmental factors, source types, and frequencies. Attenuation is frequency-dependent, with higher frequencies generally experiencing greater attenuation. The surrounding environment, whether it consists of hard or soft sites, significantly impacts attenuation. Current acoustic measurement technologies, such as FFT analysis, have limitations in terms of frequency resolution and transducer capabilities.

What this paper adds: This paper adds to the existing knowledge by providing a comprehensive analysis of noise attenuation, covering point, line, and plane sources, frequency-dependent attenuation, and environmental factors. It specifically addresses the often-overlooked attenuation of infrasound and explores the unique characteristics of both natural resonance noises. The paper discusses the limitations of FFT frequency resolution and its impact on acoustic signal measurement, suggesting potential advancements in acoustic measurement technologies to address these limitations. Additionally, it highlights the potential health implications of infrasound, including its ability to cause resonance and amplify sound levels. By offering a detailed overview and addressing specific gaps in knowledge, this paper contributes to a better understanding of environmental noise and its implications for human health and the environment.

1. Introduction

This paper explores the crucial issue of environmental noise, a topic of paramount importance to acoustic professionals. Sound and noise propagate through various media—air, liquids, and solids—via pressure fluctuations emanating from their sources. The attenuation, or reduction, of sound is influenced by multiple factors, including the environment (hard or soft surfaces), source characteristics, frequency ranges, site-specific conditions such as resonance phenomena, and climatic variables. Despite the critical nature of these factors, many experts inadvertently overlook the complex interplay between environmental attenuation and resonance, which can sometimes transform inaudible sound into audible noise. This study aims to address this knowledge gap by highlighting key areas that warrant further investigation, particularly in the realms of audible and emphasizing inaudible sound, including ultrasound and infrasound. By doing so, we seek to enhance our understanding of environmental noise and its far-reaching implications.

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Noise sources are categorized into point, line, and plane sources. Sound is what we hear, while noise is unwanted sound, with the distinction depending on the listener, environment, and circumstances. Noise is classified as audible or inaudible, with inaudible noise (infrasound and ultrasound) requiring special attention due to potential health impacts. According to ISO 7196:1995 (ISO, 2025), infrasound is defined as sound within the frequency range of 1 Hz to 20 Hz. In contrast, the International Electrotechnical Commission (IEC 60050-801:1994) defines infrasound as frequencies below 16 Hz [1].

This paper examines noise attenuation concerning sources, frequencies, and site conditions with resonance phenomena. It also addresses the limitations of current acoustic measurement technologies and suggests advancements for the field of acoustic science. By understanding these factors, we can better assess and mitigate the effects of noise on human health and the environment.

In air, liquid or solid, sound and noise are transmitted by pressure variations from its source to the surroundings. Sound is what we hear [2]. Noise is unwanted sound [3]. The difference between sound and noise depends on the listener, the environment and the circumstances. The attenuation of sound and noise varies greatly depending on the surrounding environment (hard and soft site), acoustic source types, and frequencies.

The reduction of a sound is called attenuation. For every doubling of distance, the sound level reduces by 6 decibels (dB). However, this attenuation is only applied to a single point source. There are line sound and plane sound sources where attenuations are different. For a line sound source, the noise level decreases by approximately 3 dB for every doubling of distance [4,5]. This is because the sound energy spreads cylindrically, and the sound intensity halves with each doubling of distance.

For a plane sound source, the attenuation is more complex and varies with the distance from the source [6,7]. In the near field, there is no significant attenuation. In the intermediate zone, the source behaves like a line source, while in the distant zone, it acts as a point source. The sound level decreases exponentially with distance due to the fluid's viscosity. However, the attenuations for point, line, and plane sources are frequency-dependent, which means the previously mentioned attenuations are not entirely accurate. This is the first key point of this paper, emphasizing that sound attenuation depends on the type of source (point, line, or plane) and the frequencies involved.

The attenuations for point, line, and plane sources are frequency dependent due to several factors, as demonstrated by studies on line-sources [4,5] and plane-sources [6,7]. When sound waves travel through a medium, their mechanical energy is progressively converted into heat due to friction and viscosity, a process known as absorption.

This absorption is frequency-dependent, with higher frequencies being absorbed more rapidly than lower frequencies [8]. Additionally, the scattering of sound waves depends on the wavelength of the sound relative to the size of the heterogeneities in the medium, with higher frequencies being more likely to be scattered, leading to greater attenuation [9].

The way sound energy spreads out from the source, known as geometrical spreading, also affects attenuation. For point sources, the energy spreads spherically, while for line sources, it spreads cylindrically. The spreading pattern influences how quickly the sound intensity decreases with distance, and this effect is frequency-dependent [10]. Different media, such as air, water, and solids, have different properties that affect sound attenuation. For example, infrasound (frequencies below 20 Hz) can travel long distances with very little attenuation because it is less affected by absorption and scattering [11].

The range of sound that the human ear can perceive, known as the audible range, is between 20 Hz and 20,000 Hz and varies with age. Sounds with frequencies below 20 Hz are called infrasound, and those with frequencies above 20 kHz are referred to as ultrasound or ultrasonic sound. While these inaudible sounds fall outside the human hearing range, they can still have significant health implications. Therefore, it is crucial to pay special attention to inaudible noises, including infrasound and ultrasound, due to their potential impact on health.

This paper delves into the attenuation of point and line sources, examining how these phenomena manifest across different environments. It discusses frequency-specific noise attenuation and the implications of FFT frequency resolution, shedding light on how varying frequencies impact noise levels. Additionally, the paper addresses the attenuation of natural resonance noises, which can significantly influence sound propagation in various settings. Furthermore, it highlights critical health issues associated with inaudible noise, emphasizing the potential health risks stemming from prolonged exposure to such sounds. By exploring these topics, the paper aims to provide a comprehensive understanding of noise attenuation and its broader implications for public health and environmental policy. The findings underscore the necessity for further research in this area, particularly in assessing the long-term effects of noise exposure on well-being.

1.1. Inaudible health risk issues

Human exposure to infrasound is rising due to man-made factors, prompting public concern about its safety [12]. Their study evaluated whether infrasound directly affects cardiac function by stimulating myocardial tissues from cardiac surgery patients under physiological conditions. Results indicated that higher infrasound levels (110 dBz: −11%; 120 dBz: −18%) negatively impacted contraction forces, while contraction durations remained unchanged. These findings suggested that high infrasound levels impair cardiac contractility and should inform environmental regulations [12].

Low-frequency noise (LFN), recognized as an environmental problem by the World Health Organization, is emitted by sources like HVAC systems, vehicles, and wind turbines [13]. Exposure to infrasound and lower frequency pressure waves can cause cellular damage and elicit non-linear responses in biological tissues. Chronic exposure to LFN is linked to mental dysfunction, increased heart rates, and sleep disorders. More research is needed to understand its effects on health [13].

Małecki et al. [14] investigated the effects of wind turbine infrasound and low-frequency noise (LFN) on the well-being of 129 students. Participants completed cognitive tests and questionnaires under three conditions: background noise, synthesized LFN, and wind turbine infrasound. While no significant differences in test results or symptoms were observed, a significant association was found between pre-exposure well-being and post-exposure complaints. This implies that an individual's well-being before exposure may affect their experience and reporting of symptoms afterward.

Low-frequency noise may affect cognitive function, yet a consensus on its impact is lacking [15]. Their systematic review and meta-analysis examined the relationship between low-frequency noise exposure and cognition, analyzing eight studies across four domains: attention, executive function, memory, and higher-order functions. Results indicated that low-frequency noise negatively impacted higher-order cognitive functions, highlighting the need for awareness and proactive measures to mitigate potential adverse effects in daily life [15].

Wind energy presents a dilemma between global environmental benefits and local human health, particularly regarding sleep [16]. Their study examined wind turbine noise's potential to disrupt sleep and reviews literature on its health impacts. Their research indicated that reasonable turbine siting can support healthy sleep. Advances in acoustical standards offer practical solutions for balancing wind energy development with protecting human health [16].

Exposure to intense low-frequency sounds, such as in tanks and armored vehicles, can lead to noise-induced hearing loss (NIHL) with unique audiometric patterns [17]. Their study assessed the audiograms of 68 military personnel with low-frequency hearing loss to evaluate three diagnostic methods. The sensitivity rates were 0.40 for the CLB method, 0.79 for the rM-NIHL method, and 1.0 for the

MLP(18) method, indicating the latter's suitability for diagnosing NIHL in military contexts [17].

Ultrasound (US) can produce bioeffects that may be hazardous, particularly to sensitive organs and embryos [18]. Two primary interaction mechanisms are thermal and non-thermal. This paper aims to describe models assessing acoustic safety and summarize knowledge of US-induced effects from in vitro and in vivo studies. While no harmful effects in humans have been demonstrated, physicians should be aware of potential risks and adhere to the ALARA principle for US exposure [18].

The interconnected microorganisms in Earth's ecosystems are referred to as the "Internet of Microbes." Bacteria and archaea adeptly manage energy and information through various methods [19]. Their review explored the use of sound and light as physical modifiers for managing microbial populations within holobionts. While these tools can support beneficial microbes and address holobiont diseases, improper exposure to these factors may pose significant risks that warrant attention [19].

Increased awareness of animal welfare compels breeders to consider animals' needs, particularly regarding sound [20]. Vocalizations can reveal emotional states, aiding in creating comfortable environments. However, excessive noise negatively impacts health and behavior, often unnoticed due to animals' different hearing ranges. Understanding how sound affects livestock is crucial, as it influences their physiological and emotional well-being. More research is needed to explore the connection between sound and farm animal welfare [20].

The rising human exposure to infrasound from man-made sources has led to growing public concern regarding its safety and health implications. Research indicates that high infrasound levels can adversely affect cardiac contractility, emphasizing the need for revised environmental regulations to mitigate these effects. Additionally, low-frequency noise (LFN) is increasingly recognized as a significant environmental issue linked to various health problems, including sleep disorders and cognitive dysfunction.

Findings suggest that chronic exposure to LFN can lead to mental health challenges and physiological issues, necessitating further research to fully understand these risks. Studies involving students exposed to wind turbine infrasound show that pre-existing well-being can influence symptom perception, highlighting the subjective nature of noise's impact. Consequently, addressing both environmental and health standards is critical.

Moreover, understanding the potential impacts of sound on livestock emphasizes the importance of considering animal welfare in breeding practices. Effective management of sound and noise exposure could enhance the well-being of agricultural animals, thereby improving overall productivity.

Combining insights from various studies, there is a clear imperative for both awareness and proactive measures to manage sound exposure across both human and animal populations. These findings collectively urge for enhanced regulations and guidelines to safeguard health and welfare amidst ongoing technological and environmental changes.

1.2. Attenuation of a point source

For a point acoustic source, the noise level decreases by 6 dB for every doubling of distance from the source. Attenuation of a single source noise in air is explained.

The longitudinal sound intensity for a point source in a loss-less medium with no reflections (anechoic chamber) is depicted by the following equation:

$$I(r) = \frac{W}{4\pi r^2} \tag{1.1}$$

where I = acoustic intensity (Watts/m^2), r = distance from the source in meters, W = sound power (Watts).

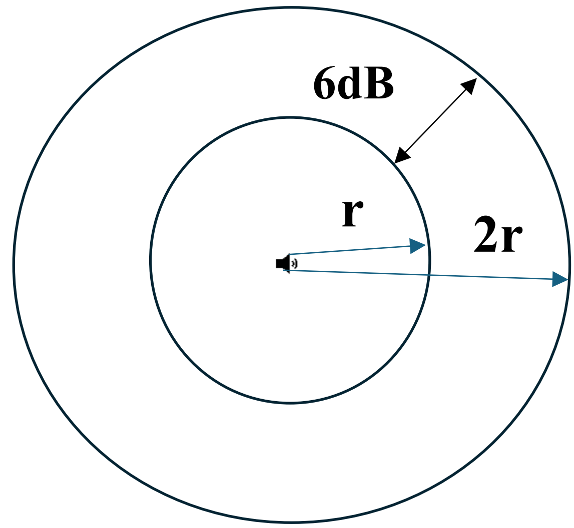

Fig. 1. Attenuation from a point source between distance r and distance 2r.

Our perception of sound loudness is logarithm. Therefore, the sound intensity SI is given by:

$$SI = 10\log_{10}\frac{I}{I_0} = 10\log_{10}\frac{W}{4\pi r^2 I_0} = 10\log_{10}\frac{W}{4\pi 10^{-12}} - 20\log_{10} r$$

where I_0 is the reference sound intensity 10^{-12} (W/m^2).

The sound intensity decay depends on distance r from the sound source:

$$-20\log_{10} r$$

The difference of the sound intensity decays between distance 2r and r is determined by:

$$20\log_{10} 2r - 20\log_{10} r = 20\log_{10} 2 = 6 \text{ dB}$$

Therefore, the sound intensity decreases by 6 dB for every doubling of distance from a single point source, provided the sound is a longitudinal wave. Fig. 1 illustrates the 6 dB attenuation from a single point source between distances (r) and (2r).

1.3. A line source attenuation

Point sources of noise pollution had been studied since the late 19th century, but line sources of that were less noticed by scientists until environmental regulations for highways and airports began in the late 1960s.

For a line source, the noise level decreases by 3 dB per doubling of distance from it. The sound intensity decay depends on distance r from the line sound source:

$$-10\log_{10} r$$

The difference of the sound intensity decays between distance 2r and r is determined by:

$$10\log_{10} 2\mathrm{r} - 10\log_{10} r = 10\log_{10} 2 = 3 \text{ dB}$$

Fig. 2 shows the 3 dB attenuation from a line source between distances (r) and (2r).

1.4. Noise attenuation of surrounding environment

There are two types of sites: hard sites and soft sites. A hard site is characterized by noise traveling away from the source over a generally flat, hard surface such as water, concrete, or hard-packed soil. These surfaces have little to no capability to absorb noise energy, resulting

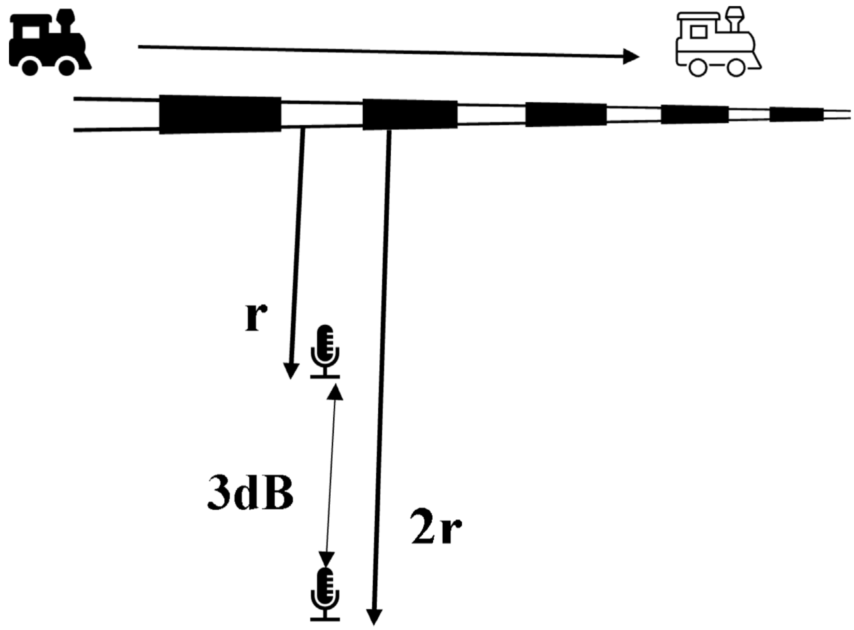

Fig. 2. Attenuation from a line source between distance r and distance 2r.

in minimal attenuation [21]. Therefore, noise attenuation is generally not considered significant at hard sites.

In contrast, a soft site exists where noise travels away from the source over porous ground or normal unpacked earth capable of absorbing noise energy. Examples of soft sites include areas with grass, trees, or other ground surfaces suitable for vegetation growth, such as farmland. The attenuation rate at soft sites includes a 1.5 dB reduction due to the ground's ability to absorb noise energy [22]. This absorption helps to reduce the overall noise level, making soft sites more effective in mitigating noise pollution.

1.5. Noise attenuation of frequencies

The absorption of ultrasonic waves in air is influenced by several factors, including frequency, temperature, humidity, and air pressure. The absorption of ultrasonic waves increases with frequency, as higher frequencies experience greater attenuation due to the increased interaction of sound waves with air molecules. This is because higher frequency waves have shorter wavelengths, leading to more frequent collisions with air molecules [23].

Additionally, the absorption of ultrasonic waves is temperature-dependent. As temperature increases, the kinetic energy of air molecules increases, leading to more collisions and higher absorption rates. This relationship is particularly significant at higher frequencies. Humidity also affects the absorption of ultrasonic waves by altering the density and composition of the air. Higher humidity levels increase the absorption of ultrasonic waves because water vapor molecules absorb sound energy more effectively than dry air molecules [24]. Lastly, air pressure influences the absorption of ultrasonic waves by affecting the density of the air. Higher air pressure increases the number of air molecules in a given volume, leading to more collisions and higher absorption rates. Conversely, lower air pressure reduces absorption [25].

Existing studies have shown that the absorption of ultrasonic waves in air can be accurately predicted using models that account for these factors. For example, Bond et al. [23] demonstrated that the absorption of ultrasonic waves in air at high frequencies (10–20 MHz) is consistent with theoretical predictions based on classical and rotational loss effects. Additionally, advancements in measurement techniques have allowed for more precise determination of absorption coefficients under various environmental conditions [23].

1.6. Fft frequency resolution

In FFT (fast Fourier transform), the frequency resolution is equal to the sampling frequency fs divided by FFT size N. Therefore, in the conventional FFT measurement, amplitude spectrums from the FFT are related to the number of measurements in the time domain.

Amplitude spectrum in quantity peak, A is calculated by:

$$A = \text{Magnitude [FFT(A)]}/N$$

where N is the number of points in the acquired time-domain signal and FFT(A) is amplitude after FFT process.

In spectrum analysis, the resolution bandwidth (RBW) is defined as the frequency span of the final filter that is applied to the input signal. Smaller RBWs provide finer frequency resolution and the ability to differentiate signals that have frequencies that are closer together in the frequency domain. Integration of the spectral components yields the power.

A significant problem in measuring acoustic signals lies in that you may not have a suitable acoustic transducer because of the limited bandwidth and the finite size of the transducer. When measuring acoustic signals, the analyzer's resolution bandwidth (RBW) must be set wider than the trace interval. If the RBW is too narrow, an acoustic signal amplitude measured with a sample detector may appear too low or be missed. The best microphone is based on MEMS due to the high performance. It should be waterproofing, windproofing, dustproof, particle-resistant and shockproof [26,27].

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Infrasound is defined by the American National Standards Institute as sound at frequencies less than 20 Hz.

1.7. Attenuation of natural resonance noises

The mode of acoustic propagation can be classified into three main types: spherical spreading, circular spreading, and linear propagation. Spherical spreading occurs in a free field, where sound waves radiate outward in all directions from a point source, resembling the shape of a sphere. Circular spreading, on the other hand, takes place within a disc of medium, where sound waves propagate in a circular manner. Lastly, linear propagation occurs along a tube or rod, where sound waves travel in a straight line [28].

The attenuation of sound varies depending on the mode of propagation. For spherical spreading, the attenuation is 6 dB per doubling of distance, meaning that the sound intensity decreases significantly as the distance from the source increases. In the case of circular spreading, the attenuation is 3 dB per doubling of distance, indicating a moderate decrease in sound intensity. Linear propagation, however, experiences no attenuation (0 dB) per doubling of distance, allowing sound to travel with minimal loss of intensity [29–31]. Infrasound experiences minimal attenuation when propagating through a stratospheric waveguide. For instance, attenuation rates are less than 2×10^{-3} dB/km for frequencies below 1 Hz [30]. Infrasound analysis is highly valuable for investigating volcanic activity and monitoring nuclear tests [32].

Sound from an ideal point source (i.e., non-directional source) spreads out spherically, causing sound pressure levels to decrease by 6 dB for each doubling of distance from the source. However, for a line of such sources or for an integration over the complete pass-by of an individual moving source, the combined effect results in sound spreading cylindrically, with sound pressure levels decreasing by 3 dB per doubling of distance [33]. Thus, there are distinct differences between the propagation of sound from an ideal point source and from moving sources. In practice, one cannot adequately assess the noise from a fixed source with measurements at a single location; it is essential to measure in multiple directions from the source. If the single source is moving, it is necessary to measure over a complete pass-by to account for sound variation with direction and time [34].

Rail noise is considered to be 70 LAeq(1 h) at a distance of 12 m from the edge of the track. It is deemed to reduce at a rate of 3 dB per doubling of distance up to 40 m and 6 dB per doubling of distance beyond 40 m [35,36]. The term 70 LAeq(1 h) refers to the equivalent continuous sound level measured over a period of one hour, with an A-weighting applied to account for the sensitivity of human hearing to different frequencies. In this context, 70 LAeq(1 h) means that the average sound level over one hour is 70 decibels, adjusted for human hearing

The attenuation of a 30 Hz signal in completely dry air can reach 1 dB/km. More realistically, in an atmosphere with relative humidities of 20% or higher, the absorption of a 30 Hz signal never exceeds 1 dB per 10 km [37,38]. Helicopters can emit infrasound at a frequency of 13 Hz, with sound pressure levels reaching up to 100 dB [39,40].

Marshall et al. [41] concluded that their findings did not support the hypothesis that infrasound causes Wind Turbine Syndrome (WTS). Even at high levels, inaudible infrasound did not appear to affect any physiological or psychological measures tested in the study participants. However, it is crucial to note that their experiments did not account for the potential resonance effects of infrasound, which could lead to serious health issues [42]. Low-frequency noise, characterized by its low speed and frequency, can be transmitted over long distances with minimal attenuation, even through walls or windows. Furthermore, the sound pressure level of low-frequency noise in an enclosed space can be amplified through resonance, potentially causing sleep disturbances. This suggests that exposure to low-frequency noise may disrupt the cortisol awakening response, leading to adverse health effects [42]. Wind turbines are considered a form of green technology. They generate electricity by harnessing the kinetic energy of wind, which is a renewable and clean energy source. Infrasound with resonance effects may harm human health. Research indicates that infrasound, particularly at frequencies and amplitudes that resonate with the human body, can lead to various health issues such as nausea, fatigue, and sleep disturbances [43]. Additionally, studies have shown that infrasonic vibrations produced by physiological processes can influence the cardiovascular and respiratory systems, potentially impacting overall health [12].

In order to accurately assess and reproduce infrasound health risk measurements, it is crucial to consider infrasound resonance phenomena. Infrasound, which consists of sound waves below the lower limit of human hearing (typically 20 Hz), can have significant impacts on human health and well-being. The resonance of these low-frequency sound waves within enclosed spaces or even within the human body can amplify their effects. When researchers neglect to account for infrasound resonance in their studies, they may significantly underestimate or entirely miss potential health risks associated with exposure to these frequencies. This oversight can lead to incomplete or inaccurate conclusions about the impact of infrasound on human health. Furthermore, the complex interactions between infrasound and various bodily systems, such as the vestibular system and internal organs, may be overlooked without considering resonance effects. Therefore, it is essential for future research to incorporate infrasound resonance analysis to provide a more comprehensive understanding of the root causes of infrasound-related health risks and to develop more effective mitigation strategies..

While humans cannot directly hear these frequencies, infrasound can interact with solid objects in a way that converts its energy into audible sound through the phenomenon of resonance. When infrasound waves encounter solid objects, they can cause these objects to vibrate at their natural frequencies. If the natural frequency of the object falls within the audible range (20 Hz to 20,000 Hz), the vibrations can produce sound waves that are audible to humans. This process effectively converts the inaudible infrasound into audible sound.

The infrasound energy causes the solid object to resonate, amplifying the vibrations. As a result, the object may emit sound waves at frequencies that are within the human hearing range. For example, a large metal structure might resonate with infrasound and produce a low-frequency hum that can be heard by people nearby. Similarly, infrasound can cause windows to vibrate, and if the vibration frequency of the window glass is within the audible range, it can produce a humming or buzzing sound that can be heard inside a building. Some musical instruments, like drums or large string instruments, can also resonate with infrasound, causing the instrument to produce audible sounds even if the original infrasound is inaudible.

By understanding how infrasound interacts with solid objects, we can see how inaudible sound waves can be converted into audible ones through the process of resonance and energy conversion. This phenomenon helps explain why we might hear sounds that originate from infrasound sources.

2. Discussion

Sound attenuation, the reduction of sound intensity, is influenced by various factors, including the type of acoustic source, frequency, and the surrounding environment. Acoustic source type significantly affects attenuation. Point sources, such as a single speaker, exhibit a 6 dB decrease in noise level for every doubling of distance. Line sources, like roadways or railways, have a less steep attenuation of 3 dB per doubling of distance. Plane sources, such as large walls or structures, have more complex attenuation patterns that vary with distance.

Frequency plays a crucial role in attenuation. Higher frequencies are generally absorbed more readily than lower frequencies due to factors like molecular interactions and scattering. This can lead to greater attenuation for ultrasound compared to audible sound or infrasound.

The surrounding environment also impacts attenuation. Hard surfaces, like concrete or water, reflect sound waves, leading to minimal attenuation. Soft surfaces, like grass or earth, can absorb sound energy, resulting in greater attenuation.

Overall, understanding these factors is essential for effectively managing and mitigating noise pollution in various settings. By considering the type of acoustic source, frequency, and environmental conditions, appropriate measures can be taken to reduce noise levels and protect human health and well-being.

Excessive noise exposure can have detrimental effects on human health. Prolonged exposure can lead to hearing loss, particularly at high frequencies. Noise can also contribute to stress, anxiety, and sleep disturbances, negatively impacting mental health. Noise can impair cognitive function, including concentration, memory, and learning abilities. Overall, excessive noise can significantly reduce quality of life, affecting daily activities and well-being. By incorporating these factors into the paper, we can gain a more comprehensive understanding of the relationship between noise and human health, emphasizing the importance of effective noise mitigation strategies to protect public health.

The infrasound measurement range is generally defined as all frequencies below 20 Hz, yet the resonance effects of both inaudible and audible sounds—including background noise—can significantly impact measurements. Current guidelines overlook the resonance effects of inaudible sounds and do not address how these effects might convert into audible phenomena. Therefore, it is essential that these guidelines be updated to incorporate these factors. Future research should explore the potential health impacts associated with both audible and inaudible phenomena.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Availability of data and material: Not applicable.

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