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Review

# Using natural means to reduce surface transport noise during propagation outdoors

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ABSTRACT

This paper reviews ways of reducing surface transport noise by natural means. The noise abatement solutions of interest can be easily (visually) incorporated in the landscape or help with greening the (sub)urban environment. They include vegetated surfaces (applied to faces or tops of noise walls and on buildings' façades and roofs), caged piles of stones (gabions), vegetation belts (tree belts, shrub zones and hedges), earth berms and various ways of exploiting ground-surface-related effects. The ideas presented in this overview have been tested in the laboratory and/or numerically evaluated in order to assess or enhance the noise abatement they could provide. Some in-situ experiments are discussed as well. When well designed, such natural devices have the potential to abate surface transport noise, possibly by complementing and sometimes improving common (non-natural) noise reducing devices or measures. Their applicability strongly depends on the available space reserved for the noise abatement and the receiver position.



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## 1. Introduction

Traffic noise significantly impacts our health and wellbeing [1]. The dominating sources are from surface transport, where road traffic noise is more important than noise from rail traffic. Indoors as long as the façade insulation is of adequate quality, the traffic noise can be sufficiently reduced to achieve a good sound environment by closing windows. With open windows or in the vicinity of dwellings, however, a decent sound environment is more difficult to guarantee, and there is a greater stress and health risk. For a sufficient improvement all tools at hand must be employed, so tackling both the source emissions as well as achieving reduction during propagation. Both traditional and novel noise control engineering approaches should therefore be mixed.

This paper focuses on natural devices reducing noise during propagation in the outdoor environment. More specifically, green noise solutions are defined as devices or measures that can be rather easily (visually) incorporated in the landscape, or that can help greening the (sub)urban environment. The following topics have been considered: stand-alone vegetation, planted surfaces (applied to faces or tops of noise walls, building façades and roofs), caged piles of stones (so-called gabions), earth berms (mounds) and exploiting ground-related effects (replacing acoustically hard ground by acoustically soft (porous) ground and roughening of ground).

Meteorological effects strongly affect sound propagation outdoors [2,3]. Where relevant, calculations have been performed to analyse noise reduction under realistic outdoor conditions including atmospheric refraction of sound, i.e. curving of sound paths due to temperature profiles and wind. Moreover, some green measures are specifically studied as a means to tackle negative meteorologically-induced effects.

The current paper reviews findings with relation to the aforementioned noise reducing devices, amongst which achievements made by the recently finished FP7 EU-funded research project HOSANNA ("Holistic and sustainable abatement of noise by natural and artificial means"). The bulk of this work is based on numerical predictions utilizing various numerical approaches, trying to optimize such devices. Although not detailed explicitly everywhere in this paper, cross-validations between various numerical techniques have been performed to gain confidence in purely numerical results, and predictions have been validated by field studies and scale-models measurements.

This paper presents ideas for several noise reducing devices rather than identifying the most suitable green noise abating solution for a given situation. The calculation results are presented relative to a well-defined reference situation that might change depending on the context. It is possible that some of the proposed designs might pose constructional problems. However, the practical restrictions related to aspects of construction are not reviewed since they are considered to be beyond the scope of this research, which aims to bring together new ideas and concepts for acoustical treatments.

Despite the growing evidence that vegetation by itself affects noise perception positively [4–8], this aspect is not treated in this paper which is concerned, primarily, with systems for physical noise reduction.

This review paper mainly focuses on road traffic noise abatement. Some calculations have been performed for realistic road traffic configurations, including multiple lanes. Other noise reducing devices and experiments have focused on the insertion loss obtained with a single point source, to which a traffic noise spectrum has been added to estimate the response to total traffic noise. A few green propagation measures for rail traffic were studied as well: low noise barriers near tramways, the effect of grass-covered ground beside a tramway track, and small berms along train tracks. This paper aims at describing the physical propagation-related principles involved and providing a general idea about the noise reductions that can be achieved with a specific measure (by citing experiments and calculation results). However, as such values often strongly depend on specific source and receiver distances, the reader is encouraged to consult the references that have been given for more detailed information.

## 2. Noise barriers

Noise barriers prevent direct line-of-sight propagation between noise sources and receivers. Diffraction of sound over their horizontal edges is typically the dominant contribution to the sound field behind the barrier. Consequently, good designs of the top could improve their efficiency without increasing the total barrier height (see Section 2.1.2). Transmission through the barrier can be kept sufficiently low e.g. by providing an adequate surface density (see e.g. Ref. [9]).

A noise barrier is especially efficient at close distances, where a deep acoustic shadow zone is formed. With increasing receiver or source distance from the barrier, its shielding decreases as the difference between the length of the path sound has to travel from source to receiver over the barrier and the length of the (virtual) direct sound path between source and receiver decreases [9]. Under downwind conditions, open-field refraction or screen-induced refraction further limits their efficiency (see Section 2.1.3). A noise barrier is also strongly influenced by the ground type [10–12]. Typically, a barrier has a higher insertion loss when placed on a rigid surface relative to a porous ground.