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Landscape depressions can create silent zones in noise polluted parks

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ABSTRACT

Excessive road traffic noise exposure in (sub)urban parks hinders its restorative function and will negatively impact the number of visitors. Especially in such green environments, noise abatements by natural means, well integrated in the landscape, are the most desired solutions. Although dense vegetation bordering the park or raised berms could come first to the mind to reduce noise exposure levels, local landscape depressions are typically underused. In this work, a case-study of a small suburban park, squeezed in between two major arterial roads, is analyzed. The spatially dependent road traffic noise exposure in the park is assessed in detail by mobile sound pressure level measurements. Local reductions of up to 6-7 dBA are found at landscape depressions with gradual slopes of only a few meters deep. It can therefore be concluded that such an efficient measure should be added to the environmental noise control toolbox for noise polluted parks.

1. INTRODUCTION

Urban parks provide essential ecosystem services in sustainable and resilient cities. In addition, they promote health and well-being of citizens in many ways [1]. Even so-called “pocket parks” show to be valuable green infrastructure [2]. Since the COVID-19 pandemic, the need for such qualitative and nearby public green spaces has increased strongly.

In the dense urban fabric, parks are often exposed to excessive environmental noise levels, characterized by an abundance of mechanical and technical sounds [3]. This will negatively impact park use and its restorative functioning. Although visual park design is still dominant nowadays, the acoustic quality of parks has increasingly attracted attention over the past decades.

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While soundscape approaches have been adopted with success [4][5][6], many urban parks are positioned very close to busy roads. In such situations, sound pressure level reductions are still important to safeguard at least some acoustic quality. In such a green environment, noise abatement by natural means is most attractive.

Various ways to achieve noise abatement by vegetative/natural solutions have been analyzed in detail before [7]. Examples are vegetated surfaces (applied to faces or tops of noise walls and on the building envelope), caged piles of stones (gabions), vegetation belts (tree belts, shrub zones and hedges), earth berms and various ways of exploiting ground-surface-related effects. Note that for many of these measures, engineering and well-informed planning is important, just like with common non-natural noise abatements.

Among these measures, berms/earth mounds are interesting since they not only provide an acoustic shadow zone, but, at the same time, preserve the so-called ground effect [8] to a large extent. Note that the latter is lost at noise walls (or steep berms).

While increasing the landscape might be most obvious, also local depressions in the landscape could potentially yield noise abatement. In this work, spatially dense measurements in an urban park, close to busy roads, are presented, where specific parts were depressed with the aim to produce localized quieter zones.

2. METHODOLOGY

2.1. Site Description

The zone under study (see Figure 1) is an elongated small park, squeezed in between the Antwerp Ring Road (R1), a highly trafficked highway, and a major local road (R10). The site under study has two depressed zones, with a path around them level with the surrounding roads. In pit 1, there is a height difference of about 2-2.5 m relative to the path. Pit 2 is roughly 5 meters deep at its lowest point. The pits are very gradually sloped (see Figure 2) and covered with (rough) grass. Note that these pits were intended to store excess water after intense rainfall. However, the measurements were performed after a long dry period near the end of the summer making the soils sufficiently porous.

Figure 1: The park under study and its surrounding road infrastructure. The two depressed zones in the park are indicated with “1” and “2”.

2.2. Mobile measurements

Portable "noise nodes", developed and validated in previous studies [9], were used. Three operators carrying a backpack, with the microphone and GPS module stuck out, repeatedly walked for 3 hours in the zone under study. The operators walked slowly to reduce their self-made noise (e.g. own footsteps). Calibration with a type-1 94-dB pistonphone was performed at the start of the measurements.

Figure 2: Person walking with a mobile microphone across pit 2.

The mobile equipment measured 1/3 octave bands at an integration period of 1/8 s. The sound pressure level measurement and the location data were linked based on the clock readings of the single board computer steering both processes. Along the walking paths, data were aggregated at fixed intervals of 5 m, with a 50 % overlap between successive aggregation points.

2.3. Noise indicator

The main noise indicator analyzed was $L_{A,50}$, the median A-weighted total sound pressure level. This indicator showed to be a stable parameter for mobile measurements, and is in general a good indicator for road traffic noise. In addition, this indicator is rather insensitive to noise events from train passages or airplane fly-overs, the latter occurring regularly during the measurement period. Clearly, for elevated noise sources e.g., the terrain undulations under study would not be very helpful in reducing exposure levels in the park.

3. MEASUREMENT RESULTS

In Figure 3, the $L_{A,50}$ exposure map is presented. The dashed white lines drawn in Figure 3 are parallel to both the R1 and the R10. Absolute levels are more or less constant along these lines, except at the depressed parts. Nearest to the R1, exposure levels up to 65 dB are observed in the park, while closest to R10, levels are near 59-60 dB along these lines. The R1 contribution is clearly dominant in this zone.

In order to assess the noise reducing effect of the pits, the middle white line can be used. At the top edges of the pits, levels are more or less constant at 59-61 dB. Inside pit 2, the largest depression, levels go down to 53-54 dB, yielding reduction of 6-7 dB for total A-weighted road traffic noise. In the less deep pit 1, levels drop to 55 dB, yielding a reduction of about 4 dB.

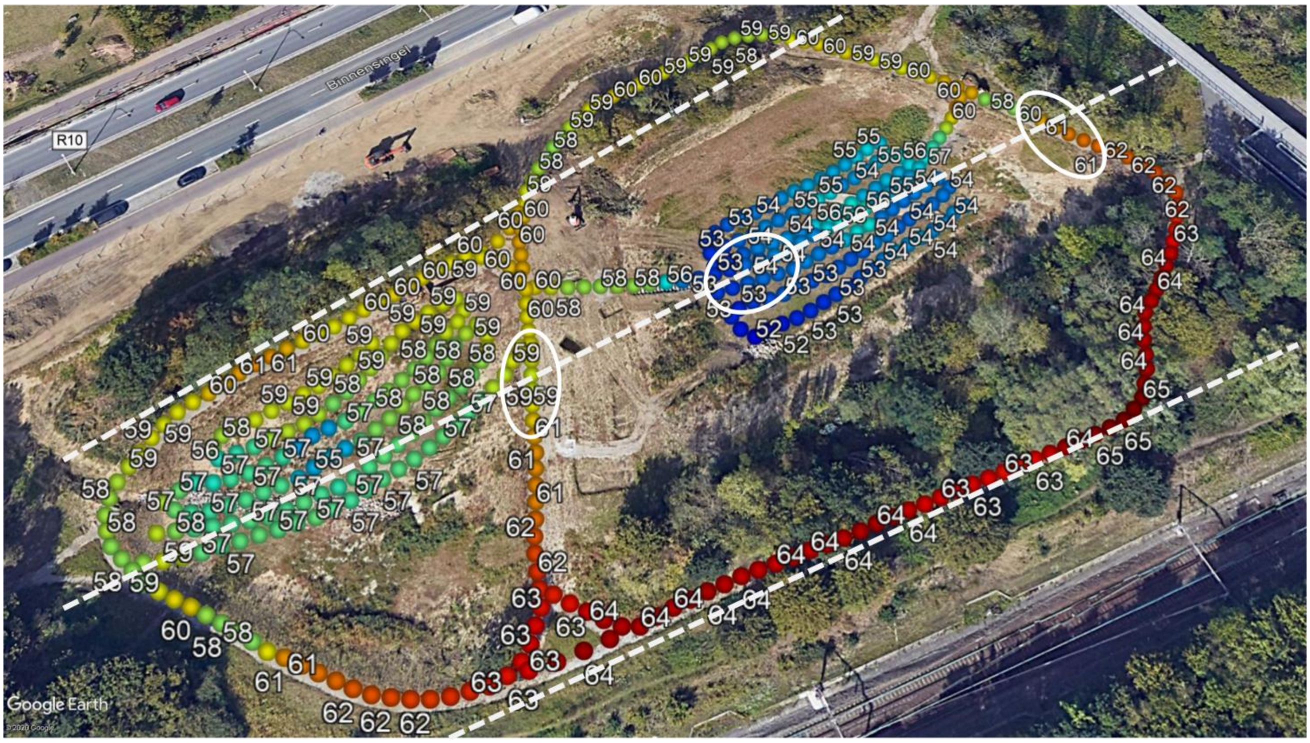

Figure 3: Measured $L_{A,50}$ exposure map, with indication of the lines parallel to the roads along which levels can be compared.

4. CONCLUSIONS AND DISCUSSION

Mobile measurements showed that with a 5-m deep pit 6-7 dB(A) reduction in road traffic noise exposure level can be achieved, even with slopes far from being steep. Deliberately introducing landscape depressions in a park near busy roads is thus a valid noise abatement measure. It should be added to the toolbox of natural surface transport noise mitigation measures, the more since gradual slopes consisting of natural grounds do hardly impact the useable park space and ecosystem services.

Although increasing the landscape might be what first comes to the mind, the measurements show that localized depressions can lead to more silent zones as well, improving the park's acoustic quality and restorative functioning. Low berms at the edges of such landscape depression could further increase noise shielding.

In addition, the strong spatial gradients in exposure between level and depressed zones might yield a relative experience of "silence" [10], even when levels in the pits are still rather high. Some positive psycho-acoustic effects can thus be reasonably expected as well.

5. REFERENCES

1. Egorov, A., Mudu, P., Braubach, M., Martuzzi, M. Urban green space and health – a review of evidence. *Report from WHO Regional Office for Europe, Copenhagen* (2016).
2. Nilsson, M., Berglund, B. Soundscape quality in suburban green areas and city parks. *Acta Acustica united with Acustica*, **92**, 903-911 (2006).
3. Nordh, H., Hartig, T., Hagerhall, C., Fry, G. Components of small urban parks that predict the possibility for restoration. *Urban Forestry & Urban Greening*, **8**, 225-235 (2009).
4. Schulte-Fortkamp B. The daily rhythm of the soundscape "Nauener Platz" in Berlin. *Journal of the Acoustical Society of America*, **127**, 1774 (2010).

5. Licitra, G., Cobianchi, M., and Brusci, L. Artificial soundscape approach to noise pollution in urban areas. *Proceedings of the international congress and exhibition on noise control engineering* (Inter-noise 2010), Lisbon, Portugal.
6. Van Renterghem, T., Vanhecke, K., Filipan, K., Sun, K., De Pessemier, T., De Coensel, B., Joseph, W., Botteldooren, D. Interactive soundscape augmentation by natural sounds in a noise polluted urban park. *Landscape and urban planning*, **194**, 103705 (2020).
7. Van Renterghem, T., Forssen, J., Attenborough, K., Jean, P., Defrance, J., Hornikx, M., Kang, J. Using natural means to reduce surface transport noise during propagation outdoors. *Applied Acoustics*, **92**, 86-101 (2015).
8. Attenborough, K., Van Renterghem, T. *Predicting outdoor sound (second edition)*. Taylor and Francis, CRC press, Boca Raton-Oxon, 2021, 690 pages (ISBN 9781498740074).
9. Van Renterghem, T., Thomas, P., Dominguez, F., Dauwe, S., Touhafi, A., Dhoedt, B., Botteldooren, D. On the ability of consumer electronics microphones for environmental noise monitoring. *Journal of Environmental Monitoring*, **13**, 544-552 (2011).
10. Cerwén, G. Listening to Japanese gardens: an autoethnographic study on the soundscape action design tool. *International Journal of Environmental Research and Public Health*, **16**, 4648 (2019).