Assessing and improving the soundscape of urban parks

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ABSTRACT

Within the LIFE+ financed project QUADMAP an approach for the analysis and assessment of so-called quiet urban areas (QUAs) is developed and tested in three European cities, that is Bilbao, Florence and Rotterdam. As an internationally agreed upon methodology for assessing soundscape is still lacking, several researchers, for example within the COST Action on Soundscape, the ISO working group and the EC/EEA Expert Panel on Noise, suggest several methods and practices from multidisciplinary research. Within the QUADMAP pilot studies these proposed methods have been applied and adjusted in accordance with practical insights gained during the project. In the pilot studies various types of QUAs, in accordance with the EU Environmental Noise Directive, have been analysed by means of noise mapping, noise measurements and field studies. Based upon these analyses interventions were proposed for the selected areas in order to improve the current soundscape, and the overall perception and valuation of the visitors / users of these areas. The aim of delineating and protecting QUAs is that areas with good acoustic quality and relatively low(er) noise levels support relaxation and reduce stress levels. Limited research though is available on the effects on perception of well being, acoustic and/or environmental quality due to interventions within or adjacent to the area under study. As the QUADMAP pilot projects will comprise an ex-ante evaluation as well, more insight will be gained on the effects of various interventions such as noise barriers, low noise pavement and nature features, on both acoustic and perception factors.

INTRODUCTION

A decade ago the EU Environmental Noise Directive 2002/49/EC (commonly abbreviated END) entered into force, requiring competent authorities to draft strategic noise maps, implement noise action plans as well as delineate and protect quiet areas. Article 8 END (p.15), for example, states that action plans for agglomerations with more than 250.000 inhabitants “shall also aim to protect quiet areas against an increase of noise”. Annex V END in addition, requires reports on actions or measures which competent authorities intend to take to preserve quiet areas, such as land-use planning, noise abatement measures, traffic management.

Practice shows though that municipalities and member states are lagging behind in, specifically, meeting the requirements on areas with good acoustic quality (Milieu 2010). An explanation could be the fact that a clear definition of quiet areas is missing. According to the directive a quiet area in an agglomeration ‘shall mean an area, delimited by the competent authority, for instance, which is not exposed to a value of Lden or of another appropriate noise indicator greater than a certain value set by the Member State, from any noise source’ (p.14). As a result a wide range of indicators is used within Europe; a comprehensive overview is provided by the QUADMAP state of the art report (www.quadmap.eu) as well as the forthcoming Good

Practice Guide of EEA. Adding to the rise of research into quiet areas and soundscape, the LIFE+ financed project QUADMAP aims to develop guidelines and tools for municipal staff in order to identify, describe or characterise, and manage quiet urban areas, in accordance with the END requirements.

QUADMAP: PROPOSED METHODS

The QUADMAP project (QUiet Areas Definition and Management in Action Plans) started in September 2011 and will finish in spring 2015. One of the main deliverables, guidelines for municipalities, has been applied in pilot cases in Bilbao, Rotterdam and Florence in order to test and, if feasible, improve the approaches and tools developed by the consortium. In the subsequent sections the overall method and the various instruments for the different phases are described.

General overview of the proposed method

Based upon a review of recent approaches in several European Member States we suggest a stepwise approach (Bartalucci et al. 2012). In Figure 1 a general overview of the proposed, and tested, method is provided, indicating the 5 steps and the key topics addressed per phase. This is largely in line with the forthcoming EEA Good Practice Guide illustrating four complementary methods, that is (1) noise mapping by modelling and calculations; (2) measurements of sound-pressure levels in situ; (3) evaluation of user/visitor experiences (i.e. the soundscape approach); and (4) expert assessments.

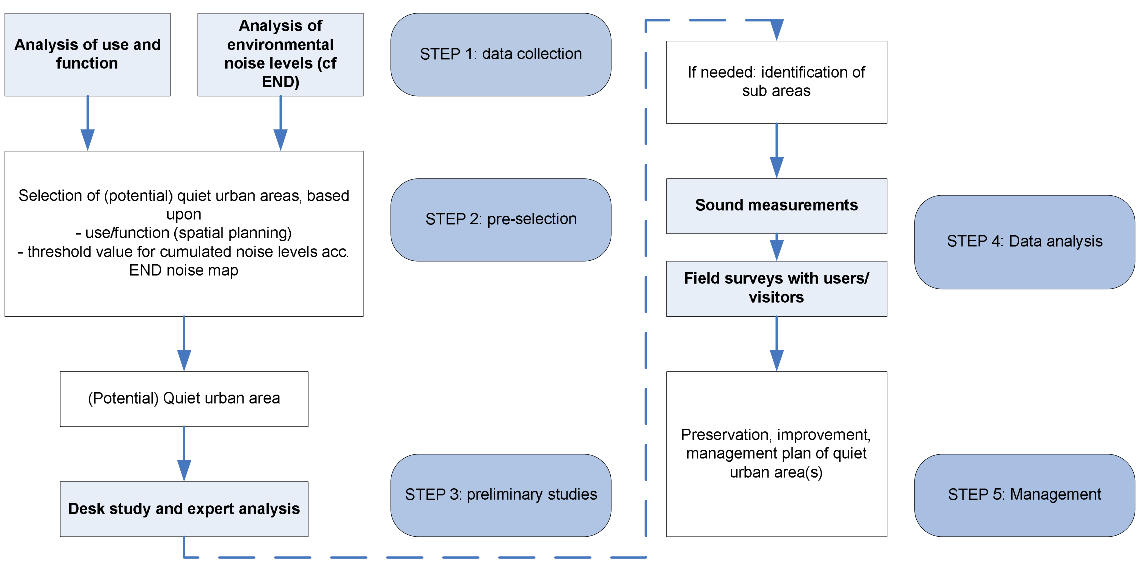

Figure 1: general overview of proposed method

Pre-selection of (potential) quiet urban areas

Within cities various types of areas can be identified based upon their specific function, such as parks, squares, playgrounds, promenades. In some instances, acoustic quality is a paramount criterion in supporting activities typical for these areas such as communicating and socialising, relaxing, reading or leisure activities.

Although noise levels in some areas might be moderate to high, (noise abatement) interventions can improve the acoustic quality. As such we propose to use two criteria for pre-selecting (potential) quiet urban areas, that is (i) use and function and (ii) noise level according to the END noise map. Regarding the latter a threshold value of 55 dB L_{den} (cumulative) is proposed, unless the national authorities have defined a different value for quiet urban areas. A complementary tool in this phase is the rQUA method developed by BruitParif and Paris (Duguet et al. 2012) This method relies on the notion of "relative sound/sound gradient/sound contrast" and analyses the energetically cumulated noise levels from road and railway traffic cf. END noise maps assigned to each vertex of a spatial grid. Areas (grid cells) with lower noise levels compared to their neighbouring 'cells' on a 250 m radius centred on each vertex. In doing so, 'quietness' is assessed not only based upon absolute noise levels below or above 55 dB Lden but taking differences in noise levels with surrounding areas into account as well. The classification of areas according to the rQUA method is represented in Table 1. Green and yellow classified areas can be considered as 'relatively quiet' urban areas, whereas orange and white classified areas will require substantive interventions in order to reduce the absolute noise levels and/or the contrasts with the acoustic climate of the surrounding area(s).

Table 1: categories of areas identified by the rQUA method

Colour	$Lden\_absolute$ dB(A)	$\Delta = Lden_{aritmetic\_average} - Lden\_absolute$
Green	≤ 55	> 10
Yellow	≤ 55	≤ 10
Orange	> 55	> 10
White	> 55	≤ 10

Other complementary approaches take societal and/or political opinions into account. For example, some competent authorities (e.g. Paris) strive for equal distribution of quiet urban areas, allowing all citizens to gain access to these areas within walking or biking distance. GIS tools, in combination with noise maps, are the most applicable tools for defining equity distribution. In addition, (on-line) surveys, internet consultations, and meetings with local actors and citizens provide relevant information on use and valuation of specific areas.

Description and analysis of quiet urban areas

A key step in the identification and preparing delineation of quiet urban areas is the analysis and characterisation of the selected areas with the aim to identify most relevant (and statistically significant) parameters explaining the appreciation or valuation of the area by its users or visitors. Three methods are proposed, that is (i) expert analyses, (ii) noise measurements, and (iii) field surveys.

The expert analysis should involve some key stakeholders from the city (administration) working in different disciplines, guided by a questionnaire developed in the QUADMAP project.

Criteria to be scored (green, orange or red, see example in Table 2 below) are the following:

(1) non-acoustic factors being landscape, natural elements, cleanliness and maintenance, and safety;

(2) general area characteristics being urban context, proximity from/to residential areas, accessibility, proximity from/to noise sources, presence of noise sources, and options for noise reduction interventions; (3) behavioural factors being number of users, distribution of users (geographically) and activities performed by users.

Table 2: part of expert questionnaire, scored for the Zuiderpark in Rotterdam

Criteria	Description	Parameters	Rating	Comments, explanations
Urban equipment	Presence and location of urban equipment	% m^2 or n. of benches, games and other facilities		
Proximity from/to noise sources	Proximity to noise sources means possible high noise levels. If users can see noise source it influences on their noise perception psychologically.	Main noise source is next to QUA and it is visible by users		Depending upon which position within the park. Along the borders of the park main roads that are visible, but ample opportunity to get deeper in the park and out of sight (and ear) of noise sources.
		Main noise source is next to QUA and it is invisible by users		
		Main noise source is far to area		
Presence of a noise sources	Presence of one or more kind of noise sources	Road, rail and airplane traffic noise		See above regarding road and railway (metro) noise
		Road and rail traffic noise		
		Road traffic noise		
Taxonomy of noise sources	Identification and classification of noise sources	Traffic sounds (cars, tractors, buses, planes)		All sources can be heard in different parts of the park and in different combinations (and perception/valuation).

In situ noise measurements, short-term during the field surveys as well as long-term, can provide crucial information on the noise levels, events, changes during day/evening/night and weekdays/weekends, as well as other sound characteristics. Cities can use these data to validate their noise maps, and in many cases provide complementary information as noise calculations (resulting in noise maps) only concern so-called environmental noise sources such as vehicles and trains. Scooters, construction works (mostly unwanted, annoying sounds) as well as birds, water and humans (mainly wanted, appreciated sounds) are not incorporated in the models used for noise calculations. Noise measurements, thus, in general provide a far better, representative 'acoustic footprint' of the area. The QUADMAP guidance provides some practical instructions for these kinds of measurements and the subsequent data analysis. Complementary to noise measurements, WAVE recordings can be made supporting psycho acoustic analyses.

Finally, field surveys are paramount for collecting the views of users and visitors of quiet urban areas (Weber 2012). According to the forthcoming EEA Good practice guide and other research (Axelsson 2012) field surveys, though time-consuming, have some interesting benefits, for example as human beings are able to distinguish intensities from various sound sources. These sources in soundscape research frequently are clustered into three main categories, that is technology, humans and nature. And, interestingly, these analyses have often proven to be stronger predictors of perceived acoustic qualities of a specific area than A-weighted sound pressure levels (e.g. Nilsson 2007a and 2007b). Secondly, visual appreciation seems to influence the perception of the acoustic quality as well. In order to capture this other non-acoustic factors have to be assessed in addition to noise indicators assessed through noise calculations and measurements. Some key variables of the field survey questionnaire provided by the project are the following: (i) sound sources and the way these are perceived, (ii) soundscape semantic differentials, (iii) valuation of area specificities such as safety, accessibility, facilities, (iv) characteristics of visits such as duration, frequency, activities, and (v) valuation of the acoustic quality as well as the overall quality.

Management of and interventions in quiet urban areas

As described before some (potential) quiet urban areas might require specific interventions on the acoustic environment or other features. In the pilot studies various interventions are planned for 2014, and the effect on the acoustic quality and the appreciation of the users of the areas will be assessed using the methods and instruments described in this paper. Results are foreseen by the end of 2014, and presented during the closing conference.

PILOT STUDIES IN URBAN AREAS

In order to validate the proposed methods several pilot areas have been selected in Florence, Bilbao and Rotterdam. In Florence six school yards are assessed and various interventions are planned during the summer of 2014, including the erection of (green, nature) noise barriers, planting trees, providing equipment (benches and study areas) and traffic management on adjacent roads. Bilbao selected two different types of areas, that is General Latorre square in the city and Santa Marina, a peri-urban area part of the cities green corridor. The first is exposed to very high noise levels from the surrounding (through)roads; according to the noise maps L_{den} levels are around 60-65 dB and L_{day} levels of 67 dB have been measured. The area will be completely restructured, nature features are added and a long rectangular fountain is placed along the main road. Rotterdam, finally, selected two parks, that is the smaller Spinozapark and the city's largest Zuiderpark. Roads adjacent to these parks will be layered with low-noise pavement in order to decrease noise exposure levels at facades of nearby dwellings as well as the acoustic characteristics and quality within the parks themselves.

Lessons-learned during the analysis of the pilot areas have resulted in minor adaptations and optimization of the methods, such as a simplification of the field survey questionnaire and a suggestion for complementary use of rQUA method for the assessment of interventions and the expected effects on 'relative quietness'. The latter is presented in Table 3 below.

Table 3: categories of quiet urban areas for analysing effects of interventions based upon the rQUA method

Colour	$Lden\_absolute$ dB(A)	Δ dB(A)
Green	≤ 55	> 10
Yellow	≤ 55	≤ 10
Orange	> 55	> 10
Blue	> 55	>-5 and ≤10
Red	> 55	≤ -5

The optimized methods will be applied during the post-intervention assessment during 2014.

Preliminary results

During the pilots data has been collected according to the methods described above, such as long-term and short-term noise measurements, noise maps and rQUAs, and field surveys. This allowed us to triangulate data and search for explanatory variables for the appreciation of the pilot areas in general and from a acoustic quality perspective. Various statistical analyses (using SPSS software) have been conducted considering the ‘dependent variables’ on (i) appreciation of the area in general, (ii) semantic differentials calm versus chaotic, and (iii) pleasantness of the acoustic environment (from the field survey questionnaire) and acoustic indicators as the ‘independent variables’ (from noise measurements).

The preliminary results suggest that, from the short term measurements, L_{A50} seems to be the most appropriate parameter to describe appreciation of users. Other acoustic indicators, i.e. L_{Aeq}, $L_{A10\text{-}LA90}$ and psycho acoustic parameters, were not (yet) statistically significant. During the next months additional analyses will be conducted; an example of preliminary results from the field survey in two parks in Rotterdam (80 respondents per park) are presented in Table 4.

Table 4: (highest) correlations of field survey parameters in Rotterdam pilot areas

Parameter	Parameter	Correlation
Soundscape evaluation	Soundscape unpleasant_pleasant	,561
Soundscape evaluation	Soundscape annoying_relaxing	,606
Overall quality	Visual pleasantness	,524
Soundscape evaluation	Soundscape characteristic_normal	,560
Acoustic quality at home	Annoyance_at home_cars	,774
Audibility of nature sounds	Importance of nature features	,427

CONCLUSIONS AND FUTURE ACTIONS

Based upon the preliminary results the following conclusions can be drawn: (i) the stepwise approach and the triangulation method are considered applicable and usable by local authorities (conclusion from the Paris workshop with French municipalities in January 2014), (ii) the main explanatory factors for appreciation of quiet urban areas are acoustic as well as 'non-acoustic' including absolute and relative sound levels, soundscape characteristics and visual characteristics.
As mentioned above the method and instruments have been slightly adjusted incorporating practical experiences in the pilot studies. During summer 2014 interventions are planned in all pilot areas; the effects of these will be analysed in a post-intervention study at the end this year. The main aim is to evaluate whether the various interventions resulted in changes (positive or negative) in the perception and/or valuation of the acoustic and overall environments. Insights gained will be used for final improvement of the project's guidelines and disseminated internationally. Results, congress papers and presentations as well as information on future actions are available at the project website, www.quadmap.eu.

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