A critical review of current policy for the assessment of night-time noise in the EU

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ABSTRACT

This paper explores issues surrounding the estimation of population exposure data in accordance with EU Directive 2002/49/EC (European Commission 2011) and, in particular, focuses on the assessment of night-time noise. It has been identified by many authors that no standardised method for estimating population exposure to noise exists. Thus, results from noise exposure studies across Member States cannot be compared reliably or combined. For sleep disturbance assessments, the issue is further compounded by the use of methodologies that are not fully understood. Significant concern exists over the use of the new L_{night} indicator, which is measured over eight hours, as sleep disturbance studies to date rarely cover this period and noise indices do not usually include L_{night}. Furthermore, assessments are performed using calculations at the position of the most exposed façade, while the impact of using this position, with respect to the bedroom, has not been fully quantified. This paper summarises the practical issues associated with the assessment of night-time noise in accordance with the requirements of EU Directive 2002/49/EC. Possible solutions are suggested including further guidance and the creation of an EU data infrastructure that would significantly improve benchmarking and comparison of future exposure studies under the terms of the Directive.

INTRODUCTION

The EU issued Directive 2002/49/EC, the Environmental Noise Directive, to establish a framework for environmental noise planning. This Directive called for the production of environmental noise maps for designated areas as well as the development of appropriate noise action plans and noise mitigation measures. Largely in response to the Directive extensive noise studies have been undertaken for the first time in many Member States. The first phase of these noise mapping studies has been completed and results have been published online by the European Environment Agency (EEA) via the "*Noise Observation and Information Service for Europe (NOISE)*"[1].

Member States were required to develop strategic noise maps by June 30th 2007, for all agglomerations[2] of over 250,000 inhabitants, all major roads with over 6 million passages a year, major railways with more the 60,000 train passages a year and major airports with over 50,000 take-off or landing movements a year. A second phase of maps, due in 2012, will also require maps to be made of agglomerations of over 100,000 inhabitants, roads with over 3 million vehicle passages a year and railways with over 30,000 train passages a year. The Directive defined two specific indicators that must be used when presenting strategic noise maps: L_{den} and L_{night}. L_{den}, the

[1] http://noise.eionet.europa.eu

[2] 'agglomeration' shall mean part of a territory, delimited by the Member State, having a population in excess of 100 000 persons and a population density such that the Member State considers it to be an urbanized area (Article 3, EU Directive 2002/49/EC)

day-evening-night noise indicator, represents the noise indicator for overall annoyance expressed in dBA while L_{night} acts as the noise indicator for sleep disturbance

A number of methodological issues concerning the implementation of the Directive have been identified and discussed by academics (Murphy & King 2010) and the European Commission also contracted a project to review the experiences of Member States in implementing the Directive (Milieu Ltd. 2010). These reports highlight a number of issues associated with the implementation of the Directive that should be considered in any review and amendment of the legislation. For example Murphy & King (2010) identified that there is no standardized method for estimating population exposure to noise; thus, results from noise studies across Member States cannot be reliably compared at present. This was also recognized in the Milieu report which noted that a number of Member States have called for a common methodology with which to measure exposed populations. Another area of concern is the use of the most exposed façade in results. For strategic noise maps, assessment points are placed at the most exposed façade (the external wall facing onto and nearest to the specific noise source) and the L_{den} and L_{night} levels are calculated at these points. L_{night} is then used to assess sleep disturbance but sleep disturbance studies to date have not used this new indicator or the façade position (WHO 2009).

This paper focuses on the issue of night-time noise area and summarizes the practical issues associated with the current policy for the assessment of night-time noise in the EU.

Noise and health

The relationship between environmental noise and public health is perhaps the most significant reason why environmental noise has emerged as a major issue in environmental legislation and policy in recent years (Berglund et al. 1999). Much research has emerged over the last two decades linking environmental noise with adverse health effects. Recently the World Health Organisation (WHO) estimated that at least 1 million healthy life years are lost every year from traffic-related noise in the western European countries, including the EU Member States (WHO 2011). In terms of strategic noise mapping, annoyance and sleep disturbance are considered to be the two most prominent adverse effects of prolonged exposure.

Annoyance is the scientific expression for the non-specific disturbance by noise, as reported in a structured field survey (European Commission 2000). Evidence of annoyance includes, for example, the reduced enjoyment of use of a garden or closing windows in order to avoid sleep disturbance. Studies have shown that noise annoyance from transportation produces a variety of negative emotions including anger, disappointment, unhappiness, anxiety and even depression (Fields 1998; Miedema 2003; Michaud et al. 2005). Many different factors will affect the extent of annoyance on any individual, for example, intermittent noise is more annoying than continuous noise and narrow band signals are generally more annoying than wider band signals. In addition it has been found that long-term annoyance is slightly, but statistically significantly, higher in the summer than in the winter (Miedema et al. 2005) while marital status and gender may significantly affect the annoyance level caused by traffic noise (Abo-Qudais & Abu-Qdais 2005).

Exposure to environmental noise may also affect people's ability to gain the appropriate amount of sleep required for the maintenance of good health. Sleep disturb-

ance is seen as a health effect on its own, but may also cause after effects such as mood changes, fatigue and other impaired functions. Research conducted by Ohrstrom & Skanberg (2004) has shown that sleep quality at home is reduced after exposure to traffic noise when compared to a quiet reference night while Carter (1996) has shown that exposure to noise during the night can lead to considerable disruption in the stages of the sleep cycle. Exposure to night-time noise can also produce a number of secondary effects (i.e. those that can be measured the day after the individual is exposed to night-time noise). The WHO LARES report notes that particular attention should be paid to night-time noise exposure as more people are affected by noise induced sleep disturbance than noise induced strong annoyance.

A further area of concern is the link between noise exposure and cardio-vascular disease (Babisch et al. 2003). The Hypertension and Exposure to Noise Near Airports (HYENA) Study found that night time noise exposure and road traffic noise were associated with increased risk of hypertension. Another worrying aspect of exposure to environmental noise includes the effect it may have on the cognitive development of children. The Road traffic and Aircraft Noise exposure and children's Cognition and Health (RANCH) Study found that chronic aircraft noise exposure affects reading comprehension and recognition memory.

Methodological issues associated with assessing night-time noise

The WHO recently released "Night Noise Guidelines for Europe" which reviewed scientific evidence on the health effects of night noise and derived health-based guideline values for noise (WHO 2009). The document notes that L_{night} is a relatively new noise indicator and, as such, sleep disturbance studies to date rarely cover the 8-hour night-time period and data are seldom expressed in terms of L_{night}. Additionally, surprisingly little information is available on the exposure of houses to night-time noise. The document also notes that further research is needed to gain an insight into the contribution of various noise sources to sleep disturbance. Furthermore, the Milieu Report notes that a major limitation of the current EU exposure-response relationships is that they do not take account the difference in exposure between the most exposed façade and the bedroom façade, as well as the difference between the outdoor exposure at the bedroom façade and the indoor exposure within the bedroom (Milieu Ltd. 2010). The report also notes that more research should be directed to a potential improvement of the prediction of subjective sleep disturbance by adding noise descriptors other than L_{night}, such as noise in the early or late parts of the night, descriptors of peak levels, or number of events.

In epidemiological studies, self-reported sleep disturbance is the most easily measurable outcome indicator, because electro-physical measurements are costly and difficult to carry out on large samples and may themselves influence sleep (WHO 2011). To date, research on noise and associated sleep disturbance has been broad and covered many different domains and disciplines. Tests have been conducted both in the field and in laboratory environments. In these tests, noise is often played over loudspeakers or headphones and the quality of the subjects' sleep is usually assessed by actigraphs or questionnaires. However, in most tests the noise indicators are assessed with respect to the subject's sleep quality and are not in terms of the new L_{night} indicator, while the noise level of interest is, logically, the indoor noise level, whereas strategic noise maps report the outdoor façade level. One exception may be the study conducted by Graham et al. (2009) who recorded both internal and

external noise during the night period, but in this case, the external monitoring position was in the vicinity of the road and not at the most exposed façade. It has been noted that recording indoor noise levels in the bedroom of each test would provide the most exact and reliable noise values, however, this process is time consuming and cumbersome (Pirrera et al. 2010).

There is also an issue with the extent of mapping required with research showing that the thresholds for noise mapping defined in the Directive may lead to a large underestimation of noise annoyance. Borst & Miedema (2005) suggest that the L_{den} limit of 55 dB should be lowered while a recent Commission report cites the WHO recommendation of lowering the L_{night} limit to 40 dB. It is questionable if today's noise calculation methods can accurately predict noise to these low levels, thus the need for a new improved method, validated at low noise levels, has emerged.

While significant work has been conducted in the area of night-time noise there still remain significant gaps in the assessment process, particularly when relating results contained in strategic noise mapping studies to actual night-time impacts. The results of the strategic noise mapping were mostly (only) graphical noise maps and community specific statistical data showing the estimated number of people within dB classes (Petz 2008). Information on the number of dwellings, hospitals and schools affected by noise levels summarized in 10 dB classes were also available. The usefulness of this data for action planning has been questioned (Petz 2008). For night-time noise assessments much more detail is required. It seems the current level of detail will not be enough to develop appropriate and consistent action plans to address night-time noise. Furthermore, the role of specific night-time noise mitigation measures is a particular area in which further detailed research is required.

With regard to action planning it has been noted that the information reported to the Commission was very diverse and the data were scattered, consequently, a comprehensive analysis of the action plans proved challenging and is still ongoing (European Commission 2011). The Eurocities Position paper[3] on the END notes that, despite the successful implementation of the END and the availability of noise maps and action plans, until then (May 2009) there was little evidence to suggest that any significant progress in avoiding, preventing and reducing environmental noise was made. The same must be true for night-time noise. It is clear that the problem is not yet fully understood and further research is needed both in the assessment and the design of mitigation measures for night-time noise.

POTENTIAL FOR IMPROVEMENT

Guidance documents

A number of guidance documents have been developed and outline approaches to the development of noise action plans. Increased guidance should improve consistency across different studies. Often guidelines are National guidance documents or as a result of European Framework projects (e.g. Silence, Qcity). In the case of sleep disturbance the Qcity project recommend the use of a measure describing the percentage of people who are highly sleep disturbed (%HSD). It is a similar measure to %HA (percentage highly annoyed) which has been widely used in the past. However this method has also been subject to criticism. Probst (2006) notes that the

[3] http://workinggroupnoise.web-log.nl/mijn_weblog/2009/07/position-paper.html

%HA concept provides a very weak weighting of levels and the results will in many cases not reflect people's opinion about a fair distribution of unavoidable hazards.

CNOSSOS-EU – Technical Group of Experts

In line with EU Directive 2002/49/EC, the European Commission decided to prepare Common Noise Assessment Methods across the EU (CNOSSOS-EU), for the purposes of strategic noise mapping, in order to improve the reliability and comparability of noise mapping results. During the Regulatory Committee on Noise (June 2010), EU Member States were invited to nominate experts to be involved in the next steps of the process related to the development and implementation of CNOSSOS-EU. The first meeting of this expert group took place in November 2010. This expert group recently established a number of working groups to assess various aspects of a common calculation method addressing the requirements of the Directive. It is hoped that these groups will consider the issue of night-time noise in detail and will suggest a more appropriate methodology for the assessment of night-time noise exposure.

Developing an EU data infrastructure

King and Rice (2009) noted that to truly achieve complete standardization in noise mapping studies, competent authorities would be required to use both the same calculation method and software format. They suggest that this could be achieved at a European level by establishing a repository making (ideally open source) software available to those authorities that may wish to avail of it. In parallel with this the creation of an EU data infrastructure could be utilized to achieve an appropriate level of consistency across different noise studies including population exposure assessments and night-noise assessments. This would significantly improve benchmarking and comparison of future exposure studies under the terms of the Directive.

DISCUSSION

Environmental noise is a serious environmental concern. It will also affect future generations and has socio-cultural, aesthetic and economic repercussions (Bjorner 2004). According to the World Health Organization, the growth in urban environmental noise pollution is unsustainable, because it involves both the direct and cumulative adverse effects on health and also adversely affects future generations by degrading residential, social and learning environments (Berglund et al. 1999). Indeed reducing transport noise both at source and through mitigation measures to ensure overall exposure levels minimize impacts on health is an objective of the EU Sustainable Development Strategy. Unfortunately, environmental noise has received little attention in the past with Dr. Rokho Kim of the WHO Regional Office for Europe recently stating "while almost everyone is exposed to too much noise, it has traditionally been dismissed as an inevitable fact of urban life and has not been targeted and controlled as much as other risks"[4].

While significant advancements have been made in Europe over the last few years there still remains the need for further research in the area of environmental noise, with particular need for improved knowledge on night-time noise. Estimates of population exposure resulting from strategic noise mapping studies are currently incompa-

[4] WHO Press Release, October 2009, "*One in five Europeans is regularly exposed to sound levels at night that could significantly damage health*".

rable due to the significant differences in estimation methodology. Additional concern exists over the use of façade levels to determine sleep disturbance while the WHO have identified that further research is needed regarding the use of the L_{night} indicator to assess sleep disturbance. The WHO Night Noise Guidelines also recognize that there is a need to conduct further research to analyze the contribution of various noises to sleep disturbance while the authors believe the role of night time noise mitigation measures has not yet been adequately developed.

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