An estimate of the global exposure to environmental noise

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Introduction

A growing percentage of the world's population lives in cities. Here, the quality of life is affected by many agents, including the exposure to environmental noise from road, rail and air traffic, from neighbours, from industries and leisure. The long term exposure to environmental noise represents a potential danger to public health, to the value of properties and to learning abilities, particularly in children. Nevertheless, the political attention for this issue has significantly reduced over the last two decennia. One possible explanation for this lack of political interest is the inconsistency in exposure data. Many statements refer to the aggregated effects rather than to the exposure, and statements about the exposure build on field data that suffers from low reliability. This is due to the diversity in assessment methods, in the size of the assessment sample and in the scope of the assessment. The European Noise Directive (2002/49.EC) is the most recent and possibly the most complete attempt to assess exposure data for a large population. One of the objectives of the Directive is to collect and interpret reliable data about the noise exposure of the European people. The current paper uses this dataset, incomplete and unreliable as it currently may be, to make a new attempt to estimate the exposure to noise for the population of the European Union (EU27) and of the world.

Data from noise mapping

Noise mapping data is reported to the European Commission in the form of tables, showing numbers of exposed people in noise exposure classes with 5 dB increment. The exposure is expressed in the standard European indicator L_{den}. The data reported so far has been published on www.circa.europa.eu. The data is far from complete and the quality of the data lacks consistency due to the application of different prediction methods and due to different interpretations and practices. Nevertheless, it is likely to be the best basis for an exposure assessment ever. For the purpose of the current paper, the data was used from summer 2008. In the mean time, more data has been added and it is expected that the set will be completed in the current year. For the current analysis, the chosen data set comprises results from 22 agglomerations in the UK, 6 agglomerations in The Netherlands (where the data for 60 different cities constituting these agglomerations were analyzed), 3 agglomerations in Sweden, 1 in Finland, 6 agglomerations in Germany and 2 in France, where the data for 20 Paris urban sections (the so-called arrondissements) were available separately. As from 2012, the data for the second round of noise mapping will become available. At present, initiatives are on their way to improve the quality and consistency. The approach to extrapolation presented in this paper could well be applied to this improved data set.

Simplifications

In order to assess the overall exposure to noise for the European people, an extrapolation has to be made. Before we embark into this extrapolation, some significant simplifications have to be made.

Only urban areas

The noise mapping data to be reported to the Commission includes agglomeration data and data for major roads and railways outside of these agglomerations. From the data available for The Netherlands, it was found that the contribution of major roads and railways is far less important than that of urban traffic. This conclusion is most likely to be correct for other countries, as:

- Only a limited number of Dutch agglomerations were included in the mapping, whereas the complete Dutch main road network was included.
- The Netherlands have a relatively dense network of main roads and railways outside cities.

Road traffic dominant

In addition to the previous simplification, the results for The Netherlands show, that road traffic noise exposure is far dominant over rail traffic. The following graph supports these findings.

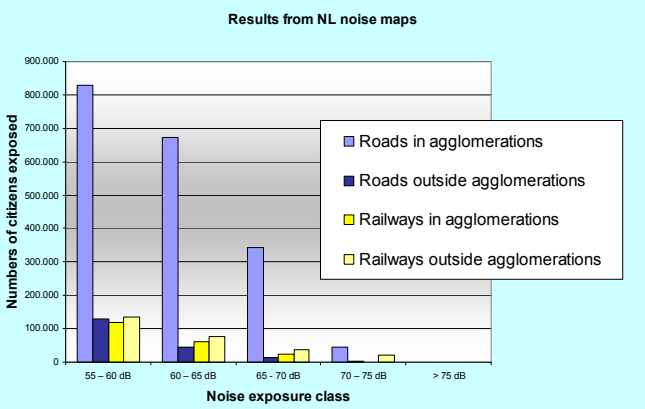

Figure 1: Results from Dutch noise maps for 6 agglomerations, 3000 km of major roads and 3000 km of major railways

This conclusion may be different in different countries. The Netherlands have a dense railway network outside cities, but a modest network in agglomerations.

Neglect industry and air traffic

When it comes to assessing the exposure for an entire country, the data from The Netherlands show, that industry and air traffic can be ignored. The error due to this simplification is probably small.

Basis for extrapolation

Theoretical basis

From a theoretical basis, it is obvious that the exposure to noise, in terms of numbers of exposed citizens, depends on the population density in a given area. In the case of free field noise propagation, there is a fixed ratio between the numbers of exposed people in consecutive classes of noise exposure levels. In a practical urban situation, this ratio is affected by the screening in built up areas. The effect is small at high exposure levels (free view at the source), and higher at lower levels. For traffic noise, quite clearly the other basic parameter is the traffic intensity. We analyzed traffic performance data (in terms of passenger kilometres per year), both for EU 27 and for seven large, so-called Millennium cities. It was found, that the area related traffic performance (passenger kilometres per year and per square kilometre) correlates very well with population density. The following graph supports this.

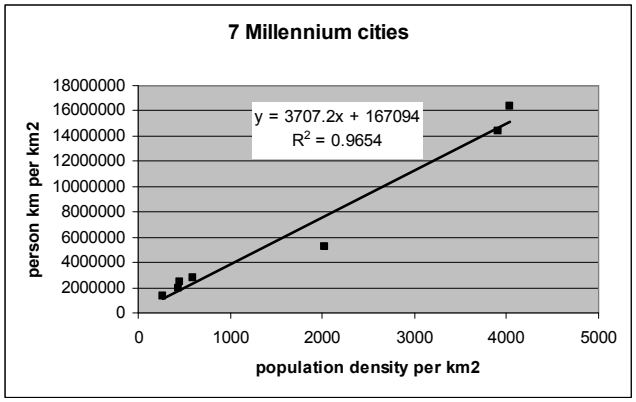

Figure 2: Road traffic performance in cities correlates very well with population density.

On this theoretical approach, we conclude that noise exposure from road traffic noise in cities mainly depends on the population density and the urban screening. If we assume that the latter is more or less comparable for the average modern city, the population density is found to be a good parameter as a basis for extrapolating mapping data.

Empirical basis

Interestingly, this conclusion coincides with that of a very old, but still valuable study carried out by W.J. Galloway et al. for the EPA (1974) [1]. The authors carried out long term noise measurements at 100 sites in 14 different cities in the United States. Their objective was to find the indicator best suited to describe the exposure, and the found the best correlation ($r^2 = 0.52$) with numbers expressed as 24-hours L_{dn}.

We used the data for the 114 aforementioned noise maps, taking the population density as the parameter, and found a correlation of $r^2 = 0.54$. The results are shown in the following graph.

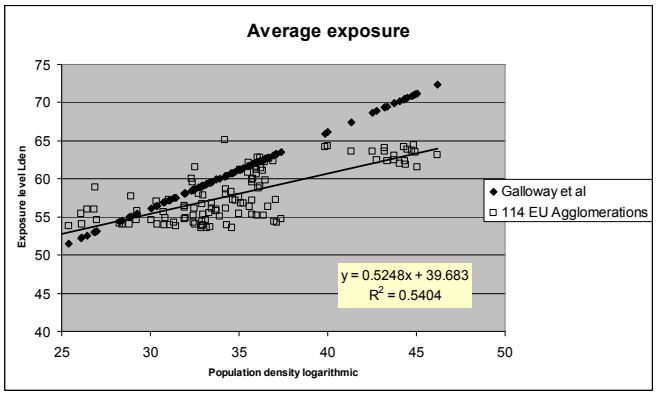

Figure 3: Average noise exposure as a function of population density for 114 European cities and agglomerations

The analysis supports the conclusion, that the population density can be used as a parameter for the extrapolation of noise exposure data.

Extrapolation to global level

In order to extrapolate to global level, an analysis was carried out on the population densities in the largest agglomerations in the world. We used the data for almost 300 of the largest agglomerations, representing 1.05 billion citizens or approximately 12% of the world's population. From the noise mapping data, we derived regression curves, correlating the percentage of people exposed to noise levels in a 5 dB band, to the population density. These regressions were then applied to the 300 agglomerations.
Thus, the noise exposure for the 1.05 billion people living in the agglomerations was assessed, based on real population density data. As a basis for further extrapolation, it was assumed that 50% of the world's population lives in urban agglomerations. This results in a total of

- 2.02 billion people in the world

being exposed to noise levels of more than 55 dB L_{den}.

Extrapolation to EU level

A similar extrapolation was carried out for the 27 Member States of the European Union. 75% of the EU27 population, comprising 490 million citizens, lives in an urban environment. The basic analysis included 38 of the largest agglomerations in EU27, with a total of 100 million inhabitants. Based on these figures, it was derived that within the 27 Member States of the European Union, a total of

- 125 million citizens in 27 EU member states

are exposed to L_{den} noise levels due to urban road traffic of more than 55 dB.

Discussion

In the current paper, an attempt was made to estimate the total number of people, both on the world and in the European Union, exposed to levels of environmental noise that are considered potentially harmful. The analysis was based on the dataset collected in the frame of the European

Environmental Noise Directive. Any analysis can only be as reliable as the data it is based on. The noise mapping data is still incomplete and partly incomparable, so the result of the current assessment has to be interpreted with care. Nevertheless, we believe that the order of magnitude is reliable. It supports the statement, that the exposure to environmental noise is a matter of great concern that deserves more attention than it actually receives.

The approach to extrapolate the exposure data on the basis of population density was found to be practicable and straightforward. The approach is worth pursuing once more complete and reliable data has become available.

Ackowledgement

A more exhaustive paper on the study reported here will soon be published in Elsevier's Encyclopedia of Environmental Health.

References

[1] Galloway, W, Eldred K, Simpson M (1974). Population distribution of the United States as a function of outdoor noise. US Environmental Protection Agency Report No. 550/9-74-009. Washington, D.C.: US EPA.