The Noise Mapping as Acoustical Preliminary Evaluation Ex Ante: an Italian Study Case

Marina Clerico, Gabriella Soffredini

Department of Environmental Engineering
Politecnico di Torino, Torino
marina.clerico@polito.it, gabriella.soffredini@polito.it

Abstract

Noise pollution, caused by traffic, industrial activities is one of the main local environmental problems: actually, about 20 percent of the European population is highly annoyed by environmental noise. The importance of this problem has been fixed by DIR 2002/49/CE, relating to the assessment and management of environmental noise, with the aim of containing and eliminating acoustical impact caused by different sources, to improve or maintain environmental acoustical quality. Italian legislation identifies in the noise mapping, (which consists in the subdivision of a land in areas, acoustically homogeneous, where limit values are fixed) the instrument put in charge for territorial acoustical management: this instrument must be suitable with the existent acoustical conditions to allow favorable development territorial plans and an effective land management.

The acoustical planning, in the case of particularly event could have a particular meaning, being not only an answer to territorial management, but also a preliminary acoustical evaluation ex ante. The noise mapping can represent a significant picture of acoustical conditions before the construction of infrastructure, such as roads or railways, to compare with the acoustical predicted impact of the new source. This research is about a study case, which aim is at first the realization of noise mapping for an Italian little town, with a project of a new road infrastructure. The noise mapping which has been done on the whole municipal territory had to confront with two aspects: a new residential urban area and a natural park as protected zone, areas with a good acoustical quality, which will be involved in the construction of a new infrastructure. In fact, the tunnel, which will connect the existing roads and highways, will have the inlet and outlet in these areas.

In this research an acoustical analysis of noise mapping has been done, integrated with the new problems, induced by the road variations and by its work construction.

1. Introduction

Community noise is defined as noise emitted from all sources except noise at the industrial workplace. Main sources of community noise include road, rail and traffic; industries; construction and public work.

In the European Union about 40% of the population is exposed to road traffic noise with an equivalent sound pressure level exceeding 55 [dB(A)] daytime, and 20% are exposed to levels exceeding 65 [dB(A)]. [1] Since World Health Organization (WHO) defines that 55 [dB(A)] is the $L_{Aeq}$ responsible for a serious annoyance we could understand the seriousness of the problem. It is well-known as the exposition to high noise levels causes sleep disturbance (if $L_{Aeq} > 30$ [dB(A)]) and others adverse health effects. These adverse effects can be medical, such as high blood pressure, mental stress, heart attacks and hearing damage. Furthermore, noise can also have a negative effect on the learning capabilities of the children.[2] Transport contributes most to environmental noise: in fact there are some noise – related Directives, to limit the noise emission from different types of vehicles. Although the noise limits have since been significantly reduced, the actual noise resulted from road transport has hardly changed, for the increase of traffic volume and also because the vehicle testing methods do not truly reflect driving conditions on the road. When all transportation noise is considered, more then half of all European Union citizens is estimated to live in zones that do not ensure acoustical comfort to residents.

Noise pollution continues to growth: this causes an increasing number of complaints from people exposed.

2. Noise policy

The major cornerstone of EU noise policy is the DIR 2002/49/CE, which defines measurement and management standards apart from detailed Directives governing specific noise emissions. The main objectives of the Directive relating to Assessment and Management of Environmental noise are to assess environmental noise through strategic noise mapping, to implement action plans to reduce noise where necessary and to maintain environmental noise quality (where it’s good) and to inform the public about noise exposure and its effects. [2] [3] On the basis of criticism shown by strategic noise mapping, competent authorities must draw up action plans to reduce noise, if necessary, or to maintain the noise quality where it’s good. The Directive does not set any limit value, nor does it prescribe the measures.
to be used in action plans, which remain at the discretion of the competent authorities. Typical examples of actions might include traffic planning, technical measures at noise sources, selection of quieter sources, reduction of sound propagation and land use planning.

In the Italian noise policy, the noise mapping represents the instrument put in charge for territorial acoustical management. This procedure consists in the subdivision of a land in areas, acoustically homogeneous, where limit values are fixed. This instrument must be suitable with the existent acoustical conditions to allow favorable development territorial plans and land management. The main national norm in Italy is the law 447/95 [4] which establishes the essential principles about the environmental protection from noise pollution. This regulation determines that towns have to classify their territory in six acoustical classes, with a noise value for different zone: zone is “each urban or mountain area, restricted by land use planning for a particular use”.

The acoustical classes have been defined for the first time by DPCM 31/03/1991 [5] and integrated by DPCM 14 novembre 1997 [6].

**Class I:** Areas particularly protected: areas in which quiet is a basic element for their use: hospital, scholastic areas, areas for rest and relax, residential rural areas, areas with particular urbanite historical and archeological interest, public parks....

**Class II:** Areas for prevailing residential use. urban areas, characterized by local traffic, low population density, limited presence of commercial activities and absence of industrial and craftsmanship activities.

**Class III:** Mixed type areas. urban areas, characterized by local or crossing traffic, middle population density, presence of commercial activities, offices and limited presence of craftsmanship activities and with the absence of industrial activities; agricultural areas in which operating machines are used.

**Class IV:** Areas of intense human activity. urban areas characterized by intense traffic, high population density, high presence of commercial activities and offices, presence of craftsmanship; areas near high communication roads and railways; harbor areas and areas with a limited presence of little factories.

**Class V:** Prevailing industrial areas; areas interested by industrial plants and characterized by lack of houses.

**Class VI:** Only industrial areas; areas characterized by industrial plants and absence of houses.

In table 1 are shown, in two different reference times, the noise values for each class, considering that day: is from 6.00 am to 22.00 pm and night is from 22.00 pm to 6.00 am, in the body of Italian specific laws. Apart the limit values shown in the table 1, there is another type of value defined by law: the noise value of quality, which represents the noise value to achieve, with available technologies or with healing plans, to realize the protection goals expressed by European and Italian laws.

This value is the same of the limit value of immission, but decreased by 3 [dB(A)].

A more useful indicator is the “noise limit value of immission”, which represents the noise value introduced in the environment by one or more noise sources: the exceeding of this limit could cause harmful effects, or negative effects on human health. The first is an indicator of environmental quality; the second is an indicator of potential risk for human health.

To guarantee, for each area, the respect of the immission limit values, the law also determines an emission limit value, which represents the noise level that every source mustn’t exceed on its border.

Some important decrees and national guidelines derive from this law, in order to apply the noise mapping, with regard to practice aspects. The regional laws (i.e. for Piemonte LR 52/2000 [7]), fix rules for the methodology of noise mapping on urbanized and flat land. [8]

**Table 1:** Limit values of L_AEq [dB(A)], day and night, for each class

<table>
<thead>
<tr>
<th>L_AEq [dB(A)]</th>
<th>IMMISSION</th>
<th>EMISSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference time</td>
<td>Limit value</td>
<td>Limit value</td>
</tr>
<tr>
<td>Day</td>
<td>Night</td>
<td>Day</td>
</tr>
<tr>
<td>CLASS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>II</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td>III</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>IV</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td>V</td>
<td>70</td>
<td>60</td>
</tr>
<tr>
<td>VI</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>

The acoustical management which derives from the Italian law is wider than what expressed by DIR 2002/49/CE[3]; in fact the aim is not only an evaluation of criticism, but also a characterization, for each par of a land, of acoustical value.

**3. The application of noise mapping**

The methodology of noise mapping has been applied to a town near Turin (Italy), in the framework of contract of research, and an acoustical class and the corresponding limit value, has been assigned to each part of municipal territory. The particularity of this research is a project for a new road infrastructure in this territory: in this case the acoustical planning could have a particular meaning, being not only an answer to territorial management, but also a preliminary acoustical evaluation ex – ante. In fact, the noise mapping executed in accordance with the legal requirements, can represent a significant picture of acoustical conditions, by characterization of the typology of the areas involved in the new road construction, particularly in the tunnel’s entrances: it is about residential areas, acoustically in class from I to III, so with a good acoustical condition.
The new road’s construction has been required and strongly wanted by the city because it represents a solution to the heavy conditions determined by traffic flow, inside the urbanized area, even the historical center, at the moment.

Although this infrastructure, in predominance in the underground, is considered necessary and useful for the environmental improvements, some areas could have a significant worsening of their environmental quality, caused by noise pollution, as well as chemical pollution induced by the presence of the tunnel’s entrances and by the variation of traffic flows.

This public work introduces a beltway, modifying not only the traffic conditions of the urban zone, but also changing the traffic flows of a wider area, connecting different state roads and a highway. The modification induced consents to foretell a growth of the traffic volume, in the tunnel zone compared to old urban arteries; it is more difficult the determination of the noise pollution generated, that depends on characteristics of traffic, as different fluidity, velocity, speed limits and the percentage ratio between heavy and light vehicles.

The analysis consists in the study of three different zones:

1. A good quality residential zone, near a natural park, acoustically classified in class I and II, where there will be the entrance of the tunnel and the relative technological plants
2. A mixed zone, with residential, commercial and craftsman shift, acoustically classified in class II and III, where there will be the other entrance with a roundabout for the traffic regulation;
3. A residential zone, with mixed zones, commercial or industrial, in class II or III with the presence of a critical receiver in the class I (as a nursery school and a primary school).

In all these zones, the traffic flow will be strongly modified, because of

- the increasing of passages
- the variation of temporal distribution of traffic flows during the day and especially during the night
- the different percentage ratio between heavy and light vehicles

The evaluation of the acoustical impact on a wide territory needs a clear and significant, even if approximate, source evaluation. This evaluation should be made looking at different parameters as vehicle types, speeds, longitudinal profiles and traffic flows, according to 2003/613/EC [9].

The availability of such evaluation to compare the situations before and after construction is crucial for the objectivity of the analysis, which would otherwise be based on a purely subjective perception of the acoustical improvement and not on a substantial technical evaluation.

In fact, in the design phase of the infrastructure a clear comparison between the problems which are going to be solved and ones that will be worsened, is missing. Moreover, by definition, the acoustical impact evaluation needs to be founded on a wide monitoring of the territory which will be the reference basis to be compared with the acoustical level generated by the new acoustical source (according to the DPSIR model); a real “long term” reference of the pre-existing conditions must also include historical data to include all possible scenarios, and the relevant evolution.

In the same way the status monitoring must consider all different possible scenarios, with their evolution in time as “long term” reference.

The historical basis of the $L_{A_{eq}}$ connected to the noise mapping, is necessary to have meteo statistical data as required by 2003/613/EC[9] for meteorological correction and calculation on long term levels, introducing pressure values obtained in favorable and in homogeneous sound propagation conditions.

In accordance with Italian laws, acoustical measurements in third zone have been executed (Fig.1) during the acoustical classification procedure because this area is considerable a critical site for:

- the presence of a school complex
- the vicinity of a road
- the high percentage ratio of exposed population in the residential area.

![Figure 1: Measurement of the acoustical conditions in front of the road: example of a part of time history](image)

At the moment, the traffic flow induces in the third zone the values higher than limits for the relative acoustical class, with a $L_{A_{eq}} = 62 + 67$ [dB(A)] measured next to the road. Indeed there is a study in progress to design solutions to reduce noise pollution till the compatibility with a school (class I) and a residential use (class II-III) with the limits of table 2.

### Table 2: Limit values of $L_{A_{eq}}$ [dB(A)], for the class corresponding to scholastic and residential uses.

<table>
<thead>
<tr>
<th>$L_{A_{eq}}$ [dB(A)]</th>
<th>IMMISSION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Value type</strong></td>
<td><strong>Limit value</strong></td>
</tr>
<tr>
<td>Reference time</td>
<td>Day</td>
</tr>
<tr>
<td>I</td>
<td>50</td>
</tr>
</tbody>
</table>
To obtain a more significant territorial knowledge of the acoustical climate further long term measurements have been started also out of critical emergency areas. Some of these measurements have been executed in the zone 1 (good quality residential area) now involved in the new road project: in those cases the available measurements will be used as “ex-ante” reference. An example of favorable noise propagation condition in Zone 1 is shown in Fig.2 and 3 (day and night time).

![Fig.2: Day time measurement in zone 1](image)

![Fig.3: Night time measurement in zone 1](image)

Finally it is mandatory for future monitoring to calculate the equivalent noise levels according both the National and European laws in terms of reference time (day/night, day/evening/night) in order to achieve annoyance indicators coherent with the European requirements.

4. Conclusions

The analysis executed shows, as obvious, that the movement of the traffic from the urban area to the city’s periphery represents a movement of the problem, with a lower percentage ratio of exposed. In particular, the acoustical exposure indicator “percentage of exposed” responds to a compatibility approach, but not to a principle of environmental sustainability, clearly underestimating the acoustical problem in the areas not used as human residential sites: this is also in contrast with the DIR 2002/49/CE objective “to maintain noise quality where it is good” and not applying the concept of “to avoid harmful effects of noise exposure from all sources and to preserve quiet areas”.

The Italian body of regulations about noise mapping requires territory acoustical classification, but instrumental monitoring is expressly required only for critical emergency sites; therefore a wider availability of a significant territorial knowledge of the acoustical climate becomes the condition to successfully use the noise mapping as an instrument to manage the effects of the infrastructural changes.

Following this approach, a preliminary (first approximation) monitoring executed within the noise mapping procedure is then the basis of such acoustical climate database, allowing a better evaluation of the impact of new sources of noise pollution on some parts of the territory.

A territorial status monitoring represents a significant evaluation of environmental, historical and social dimension of the examined territory, and therefore it represents a complete sustainability indicator and not only an acoustical compatibility indicator.

5. References