RESEARCH ON SUBJECTIVE NOISE IN POZUELO DE ALARCÓN, SPAIN

Miguel Ausejo and Manuel Recuero.

Email: mausejo@i2a2.upm.es, manuel.recuero@upm.es

María del Carmen Morillo.

Email: cmorillo@topografia.upm.es

The complete accomplishment of a noise map includes making a subjective study of the population. The more suitable tool is to carry out surveys among different sectors of the society. This paper analyzes the results obtained of the noise surveys carried out to the neighbourhood of a small city in Spain. Specific surveys were designed and they were distributed to several inhabitants of the city. The area under study was the populated area, corresponding to 22 of the 43 total square km.

A total of 228 valid surveys had been obtained, taking out social conclusions to reduce the noise and to improve the life quality of neighbours of the studied area. Several conclusions are extracted of the study, as social conscience, noise subjective evaluation, noise effects on people and economical valuation of noise. Also a brief correlation between measurements and subjective answers has been made.

1. Introduction

In order to elaborate noise actions plans, they “should be drawn up by the competent Authorities in consultation with the public” [1]. As all the information on environmental noise and its effects must be available to all population [1], and “annoyance means the degree of community noise annoyance as determined by means of field surveys” [1]; therefore it is completely necessary to carry out socio-acoustic surveys to population when noise mapping to develop correct action plans.
2. Socio-acoustic surveys specific design

2.1 Generic guidelines

First socio-acoustic surveys designed by the Instrumentation and Applied Acoustic Research Group (I2A2) were done more than twelve years ago by sociologists, engineers and statisticians. Those surveys have been updated and modified up to now.

During these years, socio-acoustic surveys have been done in several areas, countries and languages. Mentioning some of them, I2A2 has surveyed Buenos Aires (Argentina) [2, 3], Valdivia (Chile) [4], Lima (Peru), Madrid and Palma de Mallorca (Spain), adapting the questionnaires to the environment. Apart from that, different population sectors have been studied as: general inhabitants, teachers and students, patients and medical staff, public administrative assistants and tourists.

During all these years the questionnaire has been modified, feed backing the results obtained in order to design new questions or change those confused ones. These changes have been done following international recommendations [5]. In general terms, all the changes in the questionnaires have followed next guidelines [6, 7]:

- Progressive difficulty in the questionnaire. Easier or clearer questions go at the beginning of the questionnaire and difficulty is increasing little by little. This way a bias in the answer is avoided: “In community noise reaction surveys of a single noise source, the primary response question is usually placed before more extensive sets of questions about the same source to avoid the possibility of biasing respondents’ answers by heightening their awareness of the effects of that noise source.” [8].

- Analyze previous results to determine the rejection percentage. This way every valid response percentage is set and main questions are placed before.

- Almost all the questions are closed questions in order to have homogeneous results. In the other hand, is convenient to include several open questions and other kind of forms to make the questionnaire more attractive to the respondent.

- To determine subjective annoyance, verbal scale of continuous gradient (Likert) has been chosen, following international recommendations [6]. Several Ratings were measured by means of a verbal rating scale consisting of five categories:
  - Not at all.
  - Slightly.
  - Moderately.
  - Very.
  - Extremely.

- Although the recommendation for verbal questions is a five steps scale, several questions have been designed as a three step scale to make it easier to the respondent, avoiding more than five steps scale since it has been proved not understandable [9].

- Generic writing of questions is made in a direct and easy way, but anyway, difficult questions must be put into context.

The goal of all these guidelines is to design a questionnaire attractive to the respondent, obtaining a high percentage of valid surveys, avoiding bias in the answers, achieving better qualitative and quantitative results.
2.2 Structure of the questionnaire

The questionnaire is divided into seven different sections and it is formed by 44 questions. Sections are listed as follows:

- Sociological data: This section is formed by 11 questions, requesting information about age, gender, occupation and other sociological data.
- Accommodation: This section is formed by 4 questions, requesting information about preferences and priorities at home related to noise and other matters.
- Subjective noise assessment: This section is formed by 5 questions, requesting information about the noise perceived in the studied area.
- Noise annoyance: This section is formed by 2 questions, requesting information about sensitivity and noise annoyance in general terms.
- Subjective perception of the noise insulation: This section is formed by 1 question, requesting information about the personal subjective perception of the noise insulation of the house/dwelling.
- General noise effects: This section is formed by 4 questions, requesting information about the noise effects suffered and the daily activities interrupted because of the noise.
- “The problem of Noise” assessment: This section is formed by 17 questions, requesting information about the importance of noise awareness, economical valuation of noise, noise laws knowledge and other topics related to noise assessment in general terms.

3. Survey Execution

For the subjective study on the inhabitants’ noise perception of the selected area, a specific survey was carried out. The survey had 46 questions and 350 surveys were distributed randomly in several houses in the populated area of Pozuelo de Alarcón (Madrid, Spain).

3.1 Determination of sample size

In the estimation of the proportions in the Simple Random Sampling (N, n), considering a normal distribution of the estimator, the sample’s size is given by the expression [10]:

\[
 n = \frac{Z^2_{1-(\alpha/2)} \cdot NPQ}{\partial^2 (N-1) + Z^2_{1-(\alpha/2)} PQ}
\]  

(1)

where:

- \( n \) is the sample size.
- \( Z_{1-(\alpha/2)} \) is the percentile with 1-(\( \alpha/2 \)) order of the distribution N(0,1) or the significance value.
- \( P \) is the percentage with which the phenomenon under study is verified.
- \( Q \) is the complementary percentage.
- \( N \) is the size of the population under study.
- \( \partial \) is the maximum absolute error tolerated in the estimation.
The suppositions for the calculus of the sample’s size are:

- Population variance. The parameters “P” and “Q” are P = Q = 50%, obtaining a maximum product of them (and therefore a sample higher than necessary).
- Signification value or confidence level. In this case its 0.1, so that the confidence level is 90%.

The sample size, for a confidence level higher than 90%, is 96 surveys, and 228 valid surveys were obtained. 350 surveys were distributed, so the rejection percentage was 34.9%.

3.2 Sample’s description

The selected population were formed by people older than fourteen years old living in the area of interest. The total amount of sampling universe is 63,930 of 79,826 total inhabitants.

3.3 Representative sampling

In order to draw conclusions about the sampling universe analyzed, we checked if the sampling surveyed was a representative sample or not. To that end we compared surveyed population pyramid with the one provided by the National Statistics Institute (INE).

Analyzing this comparison (Figure 1), a very good representative sample is observed, according to the established criteria of 90% of confidence level.

![Figure 1. Comparison between surveyed data and INE data.](image-url)
4. Survey Results

4.1 General aspects

All data were statistically processed [11] in order to make a multi-variable analysis [12] and obtain conclusions about crossed factors as gender and noise.

In general terms, gender is not a significant factor, although it exists several correlations between noise and gender factors.

4.2 Annoyance

The most heard and most disturbing noise in dwellings and outside them is traffic noise. Only 6% of surveyed population think noise inside their houses is low at night. After the traffic, the second most disturbing noise at home is made by neighbours, drain pipes, garbage trucks and garages.

Generic annoyance from different noise sources is shown on Figure 2. Relating to noise annoyance, male gender is a bit more sensitive than female gender although the differences are very small as shown on other studies [13].

![Noise Annoyance](image)

**Figure 2.** Annoyance from different noise sources.
4.3 Noise effects and Noise awareness

The noise effects suffered more often by surveyed population are: concentration decrease (60.4%), nervousness (58.2%), insomnia and sleep-related alterations (53.8%), confirming other studies [14]. The daily activity more often interrupted by noise is sleeping (56.1%) and Reading or studying (41.7%).

Noise is very important to surveyed population as shown in others Spanish studies [15] and they have a great ignorance about the problems it can cause, how to react, they ignore their effects on the human health, laws related to noise and immediately solutions as shown in the following data:

- Almost all the surveyed population (95.2%) consider noise to be a very influential factor in life quality.
- The 75% surveyed think Authorities don’t fight against noise correctly; meanwhile the 71% ignore actual environmental noise laws.

Analyzing these data we can draw the conclusion that a very important diffusion about noise awareness and noise laws is needed.

4.4 Noise Assessment

Regarding the dilemma “noise versus economical value of a house freely offered for living”, about 39% of surveyed population prefer living in a very silent place even if the property offered has less value. This data is lower to others (54%) obtained in other Spanish localities [16]. Answering the question: “If you had a house freely offered for living…” the most chosen answer was: “250000€ house, moderately noisy (60 dB by day and night)” with the 42% of answers.

Regarding the matter of noise and distance to the work place, only a 5% answered they preferred a “nearby but noisy place”, compared to a 44% answering a “further but quiet place”; 40% of surveyed population prefer living in a slightly noise area placed 30 minutes away from workplace.

Approximately half the population think they don’t have enough noise insulation during day and night (40%). More than 80% of surveyed population hear traffic noise inside their houses, as it shows low noise insulation again. As insulation is directly related to noise annoyance [17], this is a very important matter.

A high part of the population (69%) would pay an extra amount of the total price of a house placed in a very quiet zone. This mean amount is 11% of the house price. Those data are higher to other Spanish studies[16].

Concerning the question “Are you willing to pay to decrease noise levels at your living area?” the 66% of the respondents are determined to pay for it. The mean value to decrease noise levels willing to pay per dwelling and per year is about 17.6€, a different amount than other Spanish localities [16, 18].

Almost all the surveyed inhabitants (89%) think City Council must use city budget to decrease noise and the option most frequently chosen was 5€ per citizen per year.
5. Comparison between annoyance and experimental measurements

$L_{\text{day}}$, $L_{\text{evening}}$ and $L_{\text{night}}$ measurements were done in more than 200 locations. Main noise source was traffic noise at all the locations. Therefore a correlation between traffic noise annoyance and traffic noise measured levels can be done at the locations where both data are available (Figure 3).

There is a great correlation between the most disturbing places (surveys) and the highest noise levels (measurements), so an effective action plan can be developed with those data.

![Figure 3. Comparison between annoyance and experimental measurements.](image)

6. Conclusions

- As shown in other studies [19], this research provides very useful data to develop noise management actions and local action plans [1].
- Noise insulation at houses has a great influence on noise annoyance.
- A high percentage of population has suffered effects on health and daily interruptions because of the noise.
- A high percentage of population is willing to pay money in order to decrease noise levels.
- $L_{\text{day}}$ and $L_{\text{night}}$ relates very well to the annoyance suffered by surveyed population although a 4-step verbal scale was set in the questionnaire.
- Mean levels of 67 dBA (Day) and 55 dBA (Night) are perceived as “highly annoying”. 
Acknowledgment

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References