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STUDY OF THE ACOUSTICAL ENVIRONMENT OF A CITY

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1. INTRODUCTION

We have done an acoustical study of a small city on the outskirts of Madrid, named "Pozuelo de Alarcón". This town has 56.149 inhabitants; the main range of age is 0-19 years (32.94%). The rate of annual rise is 5.27%. There are four perfectly defined areas, we are only going to present the results from the areas named "Station" and "Center". Over the map, measurement points have been chosen by means of a random procedure. Furthermore the measurements, we have done a opinion poll to the population with 21 questions about the acoustical environment of the town.

2. ABOUT THE MEASUREMENTS

We have done the measurements in December 1994-January 1995. The range of time is from 7 h to 22 h, measuring twice every 2 hours, during five minutes. We have taken 64 measurement points.

Used Equipament

Figure 1 shows the blocks diagram for data adcquisition and data processing. The used equipment are: SC42A Promax Pistophone, 202 Cirrus Microphone, TCD-D7 Sony DAT, Brüel & Kjaer 2610 Measurement Amplifier, Brüel & Kjaer 2230 Sound Level Meter. Data have been processed by means of a program developed by us, it provides these levels: Leq, Lmax, Lmin, Lmed, σ and others. Measurements have been taken according with the international standards: ISO 1999, ISO 362 and ISO 1996.

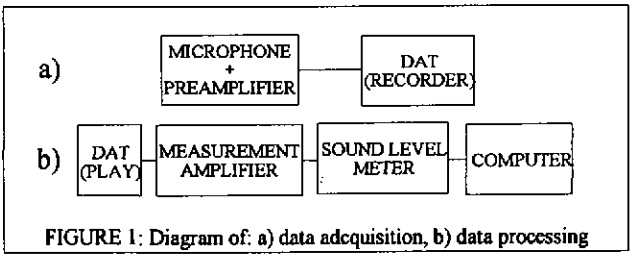

FIGURE 1: Diagram of: a) data adcquisition, b) data processing

Measurement Results

With the measurements of sound pressure level, we have obtained the average level for every hour and every point. With these levels we have obtained the equivalent level for all day in every measurement point. Table 1 shows the results of the highest level points.

Point	Leq (day) dBA	L10 (day) dBA	L50 (day) dBA	L90 (day) dBA	Lmax (day) dBA	Lmin (day) dBA
2	77.6	81.3	71.2	63.4	100.0	40.0
4	75.8	78.8	71.5	63.1	102.0	40.0
10	77.2	80.7	70.8	59.2	101.0	40.0
15	76.4	79.5	71.5	63.4	99.4	40.0
26	74.7	77.4	67.1	58.3	102.7	40.0
32	75.8	78.9	70.8	62.4	95.8	40.0
46	74.6	78.5	70.8	61.4	91.3	40.0

TABLE 1: Noise levels

Conclusions

According to the results, we can note 81.2% of the measurements have same or higher level than 60 dBA at "Center" area. 60 dBA is exceeded by 76.77% of the times at "Station" area. 23.33% belongs to the range of 70-75 dBA, 20.91% to the range of 65-70 dBA and 17.27% to the range of 60-65 dBA. The obtained values are too high for a residential area like this. The most problematic points are due to the high traffic volume. The hour range with the highest levels is from 16 to 19 hours, having 42.4% of the highest level. The hours range with the lowest levels are from 7 to 10 hours (51.5% of the lowest levels) and from 13 to 16 hours (21.2%).

At "Center" area, 29.68% of the measurements values belongs to the range 65-70 dBA, 25.81% to 60-65 dBA and 17.42% to 60-65 dBA. The highest values belong to the roads with more traffic volume. The noisiest ranges are from 13 to 16 hours and from 7 to 10 hours. The most silent ranges are from 10 to 13 hours and from 19 to 22 hours.

3. COMMUNITY OPINION

The opinion poll consists of 21 questions with several suggested answers. People could choose one or several answers. We have tried to know: which kind of noise source is the most unpleasantness, the annoyance level, physical and

psychical consequences, influence on the assessment of their house quality, whether people have planned to change the house, which hour of day and season are the noisest, whether people believe could take lawful actions against noise excesses, possible corrective actions to reduce noise level, whether people believe noise is an important factor in life quality. Lastly, we have asked about sociological data: age, cultural level and sex.

Keeping in mind the quantity of people at "Center" area (9475 people) and at "Station" area (6160 people), we have chosen the necessary amount of surveis in order to have a representative sample from the population. According to a statistical equation we have made 214 surveis at "Center" area and 140 at "Station" area, with 5.1% of error.

Conclusions

At "Center" area, the most troublesome noise is the road traffic (30.7%). This noise bothers a lot to 13.9% of people, while it bothers not much or enough to 39%. We must note that the most troublesome vehicle is the motorcycle (40.8%), followed by cars (23.7%). 49.7% of people think that their houses does not have enough acoustic isolation. 38.7% of people have not suffered noise effects, while 26.6% lose the concentration and 23.8% of people have stress.

Due to the noise, more than 50% of people wake up at night, this causes much annoyance to 34,9% of people. It is on summer when the bother is higher (76.4%). 73% of people think noise is an important factor in the life quality. 80.4% of people propose to harden the legislation, however only 24% consider theirself qualified in order to take any legal action. The corrective action of fining the motorcycles that drive without exhaust pipe is accepted for 4.9% of people. 22.4% of people agree with controlling the noise by fining the vehicles. 14.4% of people think it should put up noise barriers and furthermore, the bars, pubs and boites should close sooner.

The age of people who are polled is enough homogeneous. The teenages have not almost participated in the opinion poll. 50.5% of people were men and 49% were women, 40.3% with upper degrees and 35.6% with high school certificate.

At "Station" area, the most troublesome noise is the road traffic (43.5%), followed by the noise that neighbors cause (18.5%). Moreover it is the noise from the train (15%) that goes past this area. Motorcycles go on being the main bother (50%). The lose of concentration (20.2%) and the stress (42.2%) are the more common effects caused by the noise. 40% of people do not suffer consequences. The noise at night bothers much to this area neighbors, although 52.1% of people do not wake up at night due to the noise. The annoyance is higher on summer than on winter. Most of the residents (80%) consider that noise is a lose of life quality. 85% think we should harden the legislation against the noise. Only 25.7% of people think that they could take any lawful action. 36% of people would fine the motorcycles without exhaust pipe and 14.8% would put up noise barriers between the railway and the houses. 41.4% of people who were polled are males and 58.6% are women.

The highest range of age is from 41 to 50 years (30%), and 47.8% of people have upper graduates.

4. COMPARISON BETWEEN OBJECTIVES AND SUBJECTIVES RESULTS

28% of people think the road traffic noise bothers them no much, 27.5% a little, 17% enough and only 14% a lot. Aircraft noise does not bother to 63.6% of people, it bothers a little to 20.7% and no much to 11.4%.

The noise produced by the train passing is short in time, therefore it is a sporadic noise and the neighbors get used to it: railway noise bothers to 30% of people a little, no much to 20.7% and enough to 13.5%. According to the measurements, the main noise source is the road traffic. This fact coincides with the opinion of the neighbors that say the most unpleasant noise is the road traffic (35%).

5. PREDICTION EQUATIONS

With the Leq results and the number of vehicles per hour, we have expand an equation which allows to predict the value of the Leq. We have searched for a simple expression with a low error rate. The obtained equation is:

$$Leq = A + B \log Q \qquad (1.1)$$

Also, we have applied some equations already developed, more complex, and we can see that the differences between the results are small, therefore the use of 1 equation is justified.

As the city is divided up in different areas, acording to a geographical and acoustical criterion, we have searched for an equation for every area, besides an equation for all the city. We can see the error due to a single equation at figure 2. The used expressions are:

$$\begin{array}{ll} \textit{Station Area} & Leq = 54 + 7.3 \log Q \\ \textit{Center Area} & Leq = 52.5 + 6.1 \log Q \end{array} \qquad (1.2)$$

In the case of Europe Avenue, we could not found a equation due to the values dispersion. The equation that belongs to all the city is:

$$Leq = 54.2 + 6.5 \log Q \qquad (1.3)$$

Whether we observe the correlation coefficients for every equation, we could say that is more logical to use a single expression, for simplification. This equation is for all the city, and it has a correlation coefficient of 0.81.

5. REFERENCES

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