inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 6.6

REACTION OF INHABITANTS TO ENVIRONMENTAL NOISE

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Keywords:
ENVIRONMENTAL NOISE, RESIDENCE, REACTION, NAGOYA

ABSTRACT
A social survey of daily noise exposure of residences and inhabitants' reactions to noise has been conducted in Nagoya City which population is about 2 millions and which diameter is about 20 kilometers. More than 2000 samples have been obtained since 1982. Several questions, such as on the loudness, noisiness, annoyance, sleep disturbance and attitudes to noise environments in and around residence, were posed to inhabitants. The stored data are used to examine relationships of reaction and ratings of environmental noise by L_{Aeq}. The results are as follows. About 30% of the people express strong reaction to every question. The levels above 65dB in L_{Aeq} are unacceptable for sound noise environment irrespective of time and land use. Relations of inhabitants' reactions such as highly annoyed and L_{dn} were investigated. As a result, the reaction concerning noise of residential environments coincides with reaction curve by Schultz.

1 - INTRODUCTION
Measurements of environmental noise over 24 hours nearby residence are made in Nagoya City. Associated informations around residence and reactions of inhabitants to noise environment are also obtained [1]. This measurement system provides serial L_{Aeq} values at 10-minute intervals for 24 hours and stores these values as memory. After 1987, in addition to this parameter, L_{50} values at 10-minute intervals were obtained. Here, inhabitants' daily impression of noise in the residential environment is reported. The reactions of inhabitants to outdoor noise in terms of "loudness" and "annoyance" were classified into positive, neutral, and negative reactions, and the ratio of each reaction type and the mean noise level for it were evaluated. In addition, the results of this study were compared with those of the studies on the amount of noise and inhabitants' reactions by Schultz [2].

2 - INHABITANTS' REACTIONS
"Loudness", "noisiness" and "annoyance" are 3 attributes of the psychological discomfort of noise. "Loudness" represents subjective rating of acoustic energy and depends on energy and frequency, and its level can be approximately analyzed by the A characteristic sound pressure level. "Noisiness" is auditory discomfort and depends on not only acoustic energy and frequency, but also on pure-tone components, continuation time and impact.
"Annoyance" is non-auditory discomfort that is also associated with the relations between individuals and society such as information containing noise, tastes, accustomedness and the source of noise. Therefore, "annoyance" is also caused by factors other than physical factors such as benefits of inhabitants and their relationship with the person who produces noise. These 3 attributes of noise are considered to be closely correlated.

In our environmental survey, interviews were conducted to ask about items such as the attributes of the inhabitant, land use around the residence and impression of noise (reaction). The questions such as on the "loudness" and "annoyance" of outside and inside noise and choices of answer were as follows.
[IA] What do you think about noise level around your residence?

1. loud (+)
2. medium (0)
3. low (-)

[IB] Do you think it is noisy around your residence?

1. very noisy (+)
2. pretty noisy (+)
3. (3) noisy (+)
4. little noisy (0)
5. quiet (-)
6. very quiet (-)

[IC] Are you annoyed by it?

1. very annoyed (+)
2. annoyed (+)
3. little annoyed (0)
4. not annoyed (-)

[ID] How do you think about the noise?

1. should be abated (+)
2. desirable to be abated (+)
3. pay little attention (0)
4. pay no attention (-)

Answers are labeled as follows, according to degree of complaints:

- (+): positive reaction
- (0): neutral reaction
- (-): negative reaction

For each question item, the answer choices were classified as positive, neutral or negative reactions and the ratio (%) of each reaction type was calculated. Concerning outdoor noise in the entire city, the percentage of positive reactions was about 30% each for "loudness (IA)", "annoyance (IC), "noisiness" and "attitude to noise (ID)", suggesting that 1/3 of the inhabitants is affected by outdoor noise.

3 - AREA TYPES AND INHABITANTS' REACTIONS

The relationship between reactions (in terms of "loudness", "annoyance", etc.) to indoor and outdoor noise and land use or the noise level was evaluated. Areas were classified according to land use into residential areas (A areas) and commercial-industrial areas (B areas) and also according to the distance from roads into areas within 20 meters from a trunk road (road-adjacent areas) and others (general areas).

3.1 - "Loudness" of outdoor noise

The "loudness" of environmental noise around residence was analyzed according to the area types. The percentage of positive reactions in terms of "loudness (IA)" was 15.9% in the general A areas, 35.5%

in the general B areas showing about a twofold increase and 56.2% in the road-adjacent areas showing about a fourfold increase. Thus, the percentage of positive reactions markedly differed among the area types.
On the other hand, the percentage of negative reactions (percentage of inhabitants who feel that the noise is not loud) in the general A area was 31.6%, which was lower than the percentage of positive reactions (percentage of inhabitants who feel that the noise is loud) in this area. In the road-adjacent areas, negative reactions accounted for only 9.5% indicating that only a few inhabitants feel that the noise is not loud.
Next, the mean L_{Aeq} and L_{50} levels according to time periods of a day for each reaction type in each area type were obtained. The L_{Aeq} level for positive reactions was similar between the general A and B areas (L_{Aeq24}, 60.4 and 60.8 dB; L_{AeqM}, 58.6 and 59.1 dB; and L_{AeqN}, 52.8 and 53.2 dB; in the general A and B areas, respectively), and that for negative reactions was also similar (difference, $1 \sim 2$ dB) between the two area types. The differences in the mean L_{Aeq} or L_{50} level between the positive and negative reactions were about 10 dB in the general A areas, $7 \sim 8$ dB in the general B areas, $6 \sim 7$ dB during the daytime and 10 dB during the night in the road-adjacent areas.
On the other hand, the difference in the L_{50} level for each reaction type between the general A and B areas was $1 \sim 3$ dB. In the road-adjacent areas, the L_{50} level for positive reactions was about 10 dB higher than that in the general areas while the L_{50} level for negative reactions only slightly differed from that in the general areas.

3.2 - "Annoyance" of outdoor noise

Concerning "annoyance", the percentage of each reaction type was calculated according to the area types. The percentage of positive reactions (very annoyed, annoyed) was 24% in the general A areas, but 48% in the road-adjacent areas. Compared with "loudness", the percentage of positive reactions was increased by 8% in the general A areas and decreased by 8% in the road-adjacent areas. The percentage of negative reactions in terms of "annoyance" was slightly lower than that in terms of "loudness" in the general areas. Concerning "annoyance" around residence, the mean L_{Aeq} and L_{50} levels for each reaction type were analyzed, and the following results were obtained:

1. The L_{Aeq} and L_{50} levels for positive, neutral and negative reactions in terms of "annoyance" were similar to those in terms of "loudness".

2. The differences among the area types in the L_{Aeq} and L_{50} levels for negative reactions were slighter than those for positive reactions.

3. The difference in L_{Aeq} between positive and negative reactions was $3 \sim 4$ dB in the general A areas, $2 \sim 3$ dB in the general B areas, and $5 \sim 7$ dB in the road-adjacent areas.

4. The difference in L_{50} between positive and negative reactions was $3 \sim 5$ dB during the daytime and 2 dB during the night in the general areas and 8 dB during the daytime and 5 dB during the night in the road-adjacent areas.

3.3 - "Noisiness" of outdoor noise

Concerning "noisiness", the percentage of positive reactions (very noisy, pretty noisy, and noisy) was 19% in the A areas, and that of negative reactions (quiet, very quiet) was 40% in the general areas. The percentage of negative reactions was higher for "noisiness"" than for "loudness" or "annoyance". In the road-adjacent areas, the percentage of positive reactions was 61%, and that of negative reactions was 12%. The mean L_{Aeq} and L_{50} levels for each reaction type in terms of "noisiness" were analyzed, and the following results were obtained:

1. In the general A and B areas, the L_{Aeq} and L_{50} levels for each reaction type in terms of "noisiness" were similar to those in terms of "loudness" or "annoyance".

2. In the road-adjacent areas, the mean L_{Aeq} and L_{50} levels for each reaction type in terms of "noisiness" also did not markedly differ from those in terms of "loudness" or "annoyance" though the levels for negative reactions were $1 \sim 2$ dB for "noisiness".

4 - INHABITANTS' AWARENESS OF NOISE ENVIRONMENT AND L_{DN}

Daily L_{Aeq} obtained after addition of a penalty (10 dB) to the night is called the day-night equivalent noise level (L_{dn}) and is often used as a parameter for the assessment of environmental noise. There

have been many studies on the relationship between L_{dn} and inhabitants' reactions evaluated using a questionnaire. In 1978, Schultz reviewed the results of social surveys in various western countries and suggested a relationship between L_{dn} and inhabitants' awareness of the noise environment (the reply rate of "highly annoyed").
Subsequently, data have been added according to means of transportation. And analysis using a regression equation has been performed. These studies have generally supported the relationship between the noise level (L_{dn}) and inhabitants' reactions proposed by Schultz. Curves according to means of transportation showed that the reply rate of "highly annoyed" was 15% at an L_{dn} of 65 dB and 20% at 70 dB. They report that the L_{dn} that causes only low annoyance is 55 dB though admitting much scattering in the replies of inhabitants at each environmental noise level.
In Japan, the Environmental Agency has carried out inhabitants' awareness surveys of traffic noise including that along trunk roads. Noisiness was evaluated using a 5-grade system, and the upper 2 grades were chosen by $10 \sim 17\%$ of the inhabitants at an L_{dn} of 65 dB and by $10 \sim 25\%$ at 70 dB.
To evaluate the correlation between the results of these social surveys and those of this survey in Nagoya City, the percentage of the upper 2 grades (strong reactions) among the 6 grades for "noisiness", i.e., "very noisy" and "pretty noisy", was obtained, and its relationship with L_{dn} was analyzed. The percentage of strong reactions in terms of "noisiness" was less than 10% at an L_{dn} of 60 dB or less, but about 20% at 70 dB. The results of our survey were consistent with the above-described reaction curve obtained by Schultz.

5 - CONCLUSION

Based on data obtained by measurements of noise exposure of residence and a living environment survey in Nagoya City, we clarified the present status of inhabitants' reactions to indoor and outdoor noise and investigated the relationship between these reactions and the noise level.

- In the entire city, about 30% of the inhabitants feel that noise around their residence is loud. Thus, 1/3 of the inhabitants was affected by outdoor noise.
- Positive reactions to outdoor noise in terms of "loudness" accounted for about 16% in general A areas (residential areas), 36% in general B areas (commercial-industrial areas) and about 56% in the road-adjacent areas. The percentage of negative reactions in terms of "loudness" was 10% in the road-adjacent areas.
- For the same reaction type (positive, neutral, or negative), the difference in the noise level was small between the general A and B areas. The difference in the noise level between the road-adjacent areas and general areas was about 10 dB for positive reactions but slighter for negative reactions.
- The percentage of strong reactions to noise around residence in terms of "noisiness" was less than 10% at the L_{dn} of 60 dB and about 20% at 70 dB, which was consistent with the reaction curve shown by Schultz.

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