Questionnaire study of perceived noise impact in the residential area

- Before the noise barrier protection

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1. Background

Action 3 of the NOISUN project is intended identifying the current noise situation in the residential area before having the noise barrier protection, measured and perceived. This questionnaire study is targeted to investigate the perceived noise impact. Moreover, action A3 is related to action C1 which is targeted to identify the noise situation after the noise barrier is erected.

In the studied residential area there are many different noise sources: the highway (E20) traffic, the railway traffic (which also induces ground vibration), aircrafts, the local road traffic (Göteborgsvägen and Aspenäsvägen), the parking field/streets, activities of local people or neighbours (e.g. screaming children, loud music, slamming doors, heavy footsteps, water discharging, barking dogs, etc.), in-building facilities, maintenance or repair work (e.g. lawnmowers, drilling machines, caretaker tractors, etc.), gulls cry, etc. As perceived noise impact depends both on subjective factors (e.g. indulgent towards, or sensitive to noise) and objective factors (e.g. noise level, noise type, having a quiet side or not, noise exposure in day time or in night time), this questionnaire study will have its focus on part of the objective factors – in what extent the residents are disturb by the highway and the railway noise, because the noise barrier is to reduce noise from these two noise types.

The studied residential area as well as the location of the noise barrier is shown in Fig. 1, where the green line indicates the location of the noise barrier consisting of solar panels, the yellow line is for the extended barrier section consisting of normal panels, and the blue line is for the northern platform of the railway station Aspedalen (shown in Fig. 2) which reduces the railway noise by about 8 dB. It can be seen that the residential area can further be divided into two parts: area 1 for which the noise barrier has its full effect in reducing the railway noise and the highway noise, and area 2 for which the noise barrier has only partial effect in reducing the noise. In action C1 it will be interesting to look at the difference in perceived noise impact between these two areas after having the noise barrier protection.

As a high response rate is important for the quality of a questionnaire study, the good strategy have been applied: firstly, except a well prepared (while simplified) the questionnaire, an information letter which explains the purpose of the study was delivered to the residents one week before delivering out the questionnaire; secondly, after the response deadline, a remind
letter was delivered to those residents who had not given their answers. Moreover, as it is
Lerum municipality who delivered the questionnaire and collected the answers, people living
in the area may feel closely relevant and may more willingly give their answers. There are
also other two favoured factors: (1) people are keen on reducing the local noise impact; (2)
there are quite many retired people living in the area who have time and are willing to answer
the questionnaire.

The information letter was delivered out in the early of May and all the collected answers
were registered in an Excel data file which was ready in the early of June. The answer
distributions to each of the questions are presented in Appendix. These answer distributions
will be analysed in section 2. Further discussions will be given in section 3.

![Fig. 1 The location of the noise barrier (green line + yellow line), the railway station
Aspedalen (the blue line; see also Fig. 2), and the studied residential areas (area 1 + area 2).](image_url)
Fig. 2 The northern platform of the railway station Aspedalen.

2. Questionnaire analysis

Following ISO/TS 15666 [1] and also referring to the COST questionnaire template [2], a questionnaire suitable for the action 3 of the NOISUN project was designed. In this simplified questionnaire, 11 response scales (0 - 10) have been assigned to questions 1-28, where scale 0 is for no disturbance and scale 10 for extremely much disturbance. Moreover, except for question 28, an extra scale, ‘No idea (Vet ej)’, is provided in case people cannot answer the question by some reasons, or, simply think the question irrelevant. For questions 29 and 30, only 3 response scales, (No, Yes, No idea), are assigned. For ‘Comments’, people can write whatever they like to comment that will provide some detailed information such as what noise types have been disturbing them.

Answers following the given response scales are presented in Appendix. In the following, for simplifying the analysis, the 11 response scales are further combined into two groups: 0-5 for less disturbed and 6-10 for much disturbed.

2.1 The response rate

The questionnaire has been delivered to 369 flats/houses in the studied residential area.
The number of total returned answers is 280 and the response rate reaches 75.9%, being a quite high level. And, 182 females (65.2%) and 97 males (34.8%) have fully or partially answered the questionnaire, plus one answer without personal information provided. As counted by age group, 9 answers (3.2%) are from 18-25 year group, 33 (11.8%) answers from 26-39 year group, 86 answers (30.8%) from 40-65 year group and 151 (54.1%) from over 65 year group. These digits indicate that slightly more than half the population in the studied residential area are retired persons. As understood, by average, retired people spend more their day-time in the area.

In Table 1 the response rates for each of the questions of the questionnaire are presented. It can be seen that in general the response rates are quite high (> 70%), except normal high for Q6 (53.4%), Q27 (57.5%) and not high for Comments (31.4%). Q6 and Q27 questioned about disturbance by ‘other noise types’. As it was not exampled what are ‘other noise types’, this may lead some difficulty for people to answer these two questions. In other words, if some examples of ‘other noise types’ would be given, the response rates of these two questions could be higher than the current ones. Moreover, one shall usually not expect a high response rate for ‘Comments’ because it takes more time and effort to finish.

**Table 1  The response rate for questionnaire questions**

<table>
<thead>
<tr>
<th>Q1</th>
<th>74.0%</th>
<th>Q2</th>
<th>74.0%</th>
<th>Q3</th>
<th>73.2%</th>
<th>Q4</th>
<th>74.3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q5</td>
<td>73.7%</td>
<td>Q6</td>
<td>53.4%</td>
<td>Q7</td>
<td>73.4%</td>
<td>Q8</td>
<td>72.6%</td>
</tr>
<tr>
<td>Q9</td>
<td>72.9%</td>
<td>Q10</td>
<td>73.2%</td>
<td>Q11</td>
<td>72.9%</td>
<td>Q12</td>
<td>73.4%</td>
</tr>
<tr>
<td>Q13</td>
<td>73.4%</td>
<td>Q14</td>
<td>72.4%</td>
<td>Q15</td>
<td>73.2%</td>
<td>Q16</td>
<td>74.3%</td>
</tr>
<tr>
<td>Q17</td>
<td>74.5%</td>
<td>Q18</td>
<td>74.5%</td>
<td>Q19</td>
<td>74.0%</td>
<td>Q20</td>
<td>73.7%</td>
</tr>
<tr>
<td>Q21</td>
<td>74.5%</td>
<td>Q22</td>
<td>74.5%</td>
<td>Q23</td>
<td>74.8%</td>
<td>Q24</td>
<td>74.5%</td>
</tr>
<tr>
<td>Q25</td>
<td>75.3%</td>
<td>Q26</td>
<td>74.3%</td>
<td>Q27</td>
<td>57.5%</td>
<td>Q28</td>
<td>73.7%</td>
</tr>
<tr>
<td>Q29</td>
<td>74.8%</td>
<td>Q30</td>
<td>74.8%</td>
<td>Comments</td>
<td>31.4%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The estimated persons living in the studied residential area are about 683 (according to Lerum municipality). Using the response rate 75.9%, there would be about 683*0.759 = 518 persons who are related to answering the questionnaire. This number of persons, 518, was comparable to the counted number of persons, >=497, which was based on the information found in the returned answer sheets (to the question ‘number of persons in flat/house’ the answer options, ‘4-5’, or, ‘6 and above’, lead to some uncertainty in the total number of persons).

**2.2 The results**

In the following analysis, for being easy to discuss, the answers are further integrated into two groups, less disturbed (0-5) vs. much disturbed (6-10). Moreover, the response rate for a less or much disturbed group is relative to the total number of received answers for the given question, not to the total delivered (369) copies of the questionnaire.
2.2.1 The important noise sources

Based on the response rate for much disturbed group, the rank of important noise sources in the studied residential area are found to be:

- Rail traffic (36.5%)
- Road traffic (26.3%)
- Noise from neighbour (9.9%)
- Other noise (7.6%)
- Aircraft (6.3%)
- In-building facilities (4.8%)

This result indicates that aircraft noise is not serious for the residential area, because the area is not directly under the flight route. In-building facility noise is also not important, for that we shall thank the modern technology applied in the in-building facilities. There is one comment about water discharging noise from the neighbour, indicating potential improvement of the current sewer system.

There are about 10% residents disturbed by noise from neighbours. According to received comments, noise from neighbours can be e.g. screaming children, loud music, slamming doors, heavy footsteps, water discharging, barking dogs, etc. The potential ways to reduce disturbance from neighbours may be in two aspects: to regular residents’ behaviours, e.g. be quiet between 9 pm and 7 am, and to apply acoustical measures, e.g. replacing current doors/windows by the ones of better sound insulation, replacing current sewer system by a quieter one, carpeting corridor floors, etc.

There are about 7.6% residents disturbed by other noise types. According to the questions, other noise types differ from the asked other five noise types, i.e. rail traffic, road traffic, neighbour activities, aircraft, and in-building facilities. By reading the residents’ comments the other noise types can be found to be: maintenance and/or repair work (e.g. lawnmowers, drilling machines, caretaker tractors, etc.), motorcycles and mopeds, car parking, loud music from parked cars or from restaurant, compressor sound from gas station, newspaper delivering, gulls cry, gaping youngsters at night in the Nyebrogarden, boat traffic, etc.

Rail traffic is the most serious noise source in the studied residential area. According to the Swedish Transport Agency, on the railway, the average daily passages are 172 passenger trains (135 km/h) together with 50 freight trains (90 km/h). The residents’ comments emphasized that freight trains are the most disturbing because they also induce sensible ground vibration.

The yearly-averaged-daily traffic on the highway E20 (100 km/h, the Lerum section), in 2011, is about 14000 vehicles (for each direction), wherein about 1200 (< 9%) are trucks (90 km/h). On the local road Göteborgsvägen (50 km/h), the daily traffic is about 7200 vehicles, wherein 5.1% are trucks.
Around the middle of the barrier the highway E20 is about 50 m away from and about 3 m above Göteborgsvägen, which in turn is about 0.5~1m above the wayside ground. The railway is located between the highway E20 and Göteborgsvägen, both horizontally and vertically. The noise barrier shall be located between the railway and Göteborgsvägen, between about 4 m and 6 m from the nearest rail. The barrier height is limited to 3 m above the railhead, following the regulation of electrical safety for near track constructions. According to the noise calculations, the barrier noise reduction is over 10 dB for the railway noise while only about 4~5 dB for the E20 highway noise (because of the long distance).

2.2.2 Noise disturbances

Results presented in Tables 2 and 5 indicate that for indoors activities as well as for sleep, the rail and road traffic are most disturbing. The next disturbing is the noise from neighbours. The other noise types (see sub-sub-section 2.2.1 for examples) are nearly the same serious as the noise from neighbours. Moreover, as shown in Tables 3 and 4, the rail and road traffic noise is more disturbing when the windows are opened, or, when the residents on their balconies/patios directly exposed to the noise.

Table 2 The percentage of the residents who suffering much sleep disturbance

<table>
<thead>
<tr>
<th>Noise type</th>
<th>Difficult to sleep</th>
<th>Awakened</th>
<th>Having worse sleep quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neighbour and in-building facilities</td>
<td>5.9 %</td>
<td>8.2 %</td>
<td>8.2 %</td>
</tr>
<tr>
<td>Road or rail traffic</td>
<td>15.2 %</td>
<td>17.8 %</td>
<td>17.0 %</td>
</tr>
<tr>
<td>Aircraft</td>
<td>0.7 %</td>
<td>1.5 %</td>
<td>1.1 %</td>
</tr>
</tbody>
</table>

Table 3 The percentage of the residents whose activities in flat/house much impeded by road or rail traffic

<table>
<thead>
<tr>
<th>Activity type</th>
<th>The ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest and relaxation</td>
<td>19.0 %</td>
</tr>
<tr>
<td>Conversation</td>
<td>14.5 %</td>
</tr>
<tr>
<td>Having bedroom window opened</td>
<td>34.5 %</td>
</tr>
</tbody>
</table>

Table 4 The percentage of the residents whose activities on the balcony/patio much impeded by road or rail traffic

<table>
<thead>
<tr>
<th>Activity type</th>
<th>The ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out stay</td>
<td>25.6 %</td>
</tr>
<tr>
<td>Rest and relaxation</td>
<td>27.6 %</td>
</tr>
<tr>
<td>Conversation</td>
<td>25.1 %</td>
</tr>
</tbody>
</table>
Table 5 The percentage of the residents whose indoors activities (with closed windows) much impeded by different noise types

<table>
<thead>
<tr>
<th>Noise type</th>
<th>The ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neighbour</td>
<td>9.8 %</td>
</tr>
<tr>
<td>In-building facilities</td>
<td>3.6 %</td>
</tr>
<tr>
<td>Road traffic</td>
<td>13.8 %</td>
</tr>
<tr>
<td>Rail traffic</td>
<td>21.9 %</td>
</tr>
<tr>
<td>Aircraft</td>
<td>2.9 %</td>
</tr>
<tr>
<td>Other noise types</td>
<td>9.0 %</td>
</tr>
</tbody>
</table>

Q28 asks: Are you indulgent towards, or sensitive to environment noise? There 12.5 % answers are located within scales 6-10. Considering about 54.1% residents are over 65 year old, most of them should be indulgent towards to environment noise. And, according to [3], middle aged persons are likely to be subjectively more sensitive to noise than other age groups.

In the studied residential area about 68.5 % residents do not have access to a quiet room in their flat/house where they do not notice road or rail traffic noise even with the window ajar. About 81.5 % residents do not have access to a quiet place outdoors adjacent to their flat/house where they do not notice road or rail traffic noise. These two digits indicate the demands to reduce noise from the rail and road traffic.

3. Discussion

The quality of a questionnaire study depends on two key factors: if the questionnaire is well prepared and if the response rate is high, as the former factor aims at collecting necessary information and the latter guarantees the reliability of the answering. For this questionnaire study, the response rate is very high, as shown in Table 1 under sub-section 2.1. Thus, the information reflected by the discussions in section 2 is highly credible. Moreover, if the discussions in section 2 have clarified the information necessary for the project, then we can speak that this questionnaire study is successful.

The most important noise sources in the residential area are the rail and road traffic, with the second important one being noise from neighbours. Therefore, building up a noise barrier to reduce noise from the rail and road traffic will in a large extent diminish the impact of environmental noise in the studied residential area. And, it should be indicated that, a partial of the road traffic noise which stems from Göteborgsvägen will not be reduced by the noise barrier because Göteborgsvägen is located behind the barrier.

The noise exposure and the annoyance depend on the characters of noise sources (e.g. the noise levels, the frequency spectra, the directivities, the vertical locations, etc.) and the exposure modifiers [3]. For example, closer to or farther away from the noise sources, with or without noise shielding, reflecting or absorbing façade, with the windows closed or opened,
the average absorption coefficient of the room surface, all these factors can modify the noise exposure. Furthermore, some modifiers can be more important than others. As shown in Tables 3 and 4, the residents in the area suffer more noise disturbance when the windows are opened, or, when they use their balconies/patios. As expected, after having the noise barrier protection, the residents will suffer less noise disturbance not only when taking indoors activities but also when having their windows opened, or, when using their balconies/patios.

It was found that free comment in answering options is great. It provides detailed information about different noise types, in which way and in what extent the respondents are disturbed by the noise, their opinions on the planned noise barrier, etc. These comments are of benefit to the questionnaire analysis.

Many respondents commented that the ground vibration induced by freight train passages is very disturbing. As the noise barrier will only reduce the rail and road traffic noise but not the ground vibration, this ground vibration problem will be left as an unsolved issue.

The noise barrier on the southern side of the highway E20 was finished around the end of May, 2013, which is also the reason for a few months delay of this questionnaire study. Some respondents commented that noise reflection from this barrier would increase the noise impact in the residential area which is located on the northern side of the highway. However, this is not the case. The foundation of the noise barrier on the southern side is about 2 m or more above the highway E20. Therefore, in most situations this barrier only reflects the highway noise up to the sky. (Of course, the rocks under the barrier do partially reflect the highway noise back to the northern side.) Only under strong south wind the reflected highway noise will bend down to the ground on the northern side, while in the case the wind noise will be much stronger than the reflected highway noise.

Acknowledgement

Dag Glebe (SP) is responsible for the questionnaire design. Henrik Bengtsson and Peter Rosengren (Lerum municipality) are in charge of delivering out the questionnaire and collecting in the answering.

Reference

[2] COST TU0901 draft questionnaire_2011, by the courtesy of Christian Simmons, Simmons Akustik & Utveckling AB.
Appendix  Questionnaire result

The answer scale: 0 = not at all; 10 = vastly; No idea = irrelevant or cannot answer

Q1 – Q6: Think about the last 12 months, when you are in your flat/house - how much disturbed or bothered you by

**Q1: Noise from neighbour**

**Q2: Noise from in-building facilities**
Q3: Noise from road traffic

Q4: Noise from rail traffic

Q5: Noise from aircraft
Q7 – Q9: Think about the last 12 months, when you are in your flat/house - how much do you think the noise from the neighbours and in-building facilities hamper your sleep? Does noise from neighbours and in-building facilities lead..
Q8: You awakened

Q9: You have worse sleep quality
Q10 – Q12: Think about the last 12 months, when you are in your flat/house - how much do you think the noise from road or rail traffic hampers your sleep? Does noise from road/rail traffic lead

![Q10: You have difficulty to sleep](image)

![Q11: You awakened](image)
Q13 – Q15: Think about the last 12 months, when you are in your flat/house - how much do you think the noise from aircraft hampers your sleep? Does noise from aircraft lead to:

Q12: You have worse sleep quality

Q13: You have difficulty to sleep
Q14: You awakened

Q15: You have worse sleep quality
Q16 – Q18: Think about the last 12 months, when you are in your flat/house - do you think that noise from road or rail traffic interferes with or impedes the following listed activities

Q16: Rest and relaxation are impeded

Q17: Conversation is impeded
Q18: To have bed room windows open is impeded

Q19 – Q21: Think about the last 12 months, when you are outside your flat/house on the balcony/patio - do you think that noise from road or rail traffic interferes with or impedes the following listed activities

Q19: Outdoor stay is impeded
Q20: Rest and relaxation are impeded

Q21: Conversations are impeded
Q22 – Q27: Think about the last 12 months, when you are indoors in your flat/house with closed windows - how much disturbed or bothered you by

![Q22: Noise from neighbour](chart)

![Q23: Noise from in-building facilities](chart)
Q24: Noise from road traffic

Q25: Noise from rail traffic

Q26: Noise from aircraft
Q27: Other noise

Q28: Are you indulgent towards, or, sensitive to environmental noise?
Q29: Do you have access to a quiet room in your flat/house where you do not notice road or rail traffic noise even with the window ajar?

Q30: Do you have access to a quiet place outdoors adjacent to your flat/house where you do not notice road or rail noise?