Monitoring of noise reduction from traffic speed control

J. Jabben and C. Potma

RIVM, A. van Leeuwenhoeklaan 9, 3720 BA Bilthoven, Netherlands
jan.jabben@rivm.nl

In November 2005, in the Hague, Amsterdam, Rotterdam and Utrecht, a 80 km/u speed limit was introduced on parts of motorways in the Netherlands. The aim was to evaluate the effects on noise, air quality and the circulation of the traffic. RIVM investigated the effects of noise emission by direct measurement at the speed hauls. This paper gives the results from continuous monitoring of noise levels that was started at July 2005 and continued up to November 2006. In the presentation the average measured effects on the equivalent noise emissions at the different sites will be given. Also the consequences in the environment based noise maps are given. Furthermore, apart from the average equivalent noise levels, the statistical noise indicators L5, L10, L70 and L95 were continuously monitored. It was found that speed reduction induces more reduction on maximum noise levels than on the average (equivalent) noise levels, probably due to a more steady and even distribution of traffic numbers and speeds.

1 Introduction

As the Dutch motorway system is confronted with an ever increasing environmental impact of road use on nearby communities, traffic speed control is seen as one of a series of important measures. The environmental impact in terms of noise and air-quality is especially severe in the metropolitan areas of The Netherlands.

One of the possible measures to reduce road traffic noise as well as emissions of pollutants is a reduction of traffic speed. In May 2002 a speed enforcing system was installed on a part of the A13 motorway where it bisects a Rotterdam housing community. This system uses a set of infrared cameras mounted on overhead traffic signalling gantries to automatically detect vehicles travelling with an average speed greater than a set limit on a section of a few kilometres of the A13. The speed reduction here proved to be quite successful and as a result, in 2005 comparable systems were installed on motorway sections in Amsterdam, Utrecht, Rotterdam and The Hague. At all locations the speed limit was reduced from 100 km/h to 80 km/h.

Early in 2005 the motorway authority asked RIVM to monitor the effect of this speed limit reduction in terms of noise emissions of the road sections concerned as well as the effect on noise levels in built-up areas surrounding the motorways.

The aim of the project was to determine the effect of the speed limit reduction using long-term monitoring on all four locations so as to be able to include variations due to changes in weather or traffic density.

2 Monitoring system

The speed limit reduction system was put into effect in November 2005.

Measurements started in July 2005, allowing for an adequate period of pre-measure data collection, and were stopped in November 2006. The monitoring locations are shown in fig.1.

The monitoring equipment used was a Larson-Davis 870/875 analyser and a 2100 outdoor microphone. Data was collected using a GSM modem attached to the analyser. The microphone was mounted on top of an overhead signalling gantry as shown in fig.2.

On each location the hourly averaged LAeq as well as LAmax, L1, L5, L50, L67 and L90 for that hour were registered.

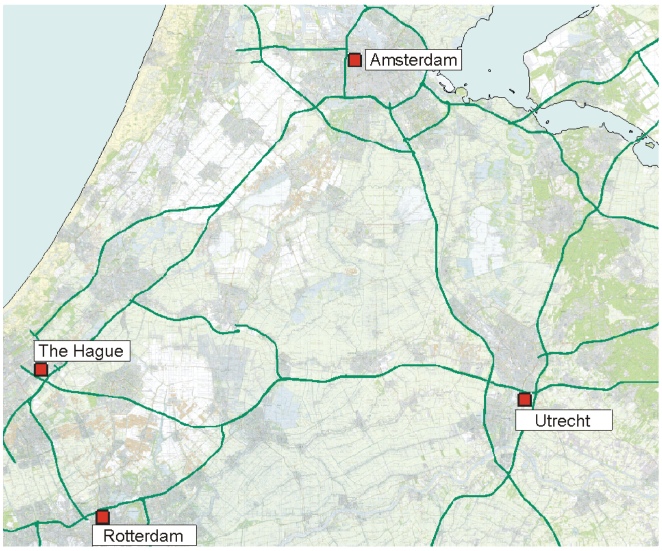

Fig. 1

Fig.2

3 Additional factors

Vehicle speed is only one of many parameters determining traffic noise emissions. A number of other factors are of importance:

- Water on the road surface. RIVM measurements since 1999 have shown an effect of rain on noise emissions of roads [1]. In particular, open asphalt-concrete road surfaces can have an increase of 3-5 dB during and right after rainfall. As modelling results showed a speed limit reduction effect of 2-3 dB on the noise emission of the road, the effect of rain on noise emission is even higher. A first-order approach was to limit the data-set to dry weather periods only.
- Air and road temperature. Previous research has shown that lower temperatures cause higher noise emissions. A probable cause is higher tyre stiffness as well as lower air-transfer attenuation. As a result, a road noise emission can be 2-3 dB higher in winter and all measurements have been corrected to a reference temperature of 10^oC[1].

The noise emission of a road is also determined by traffic volume and traffic composition. As measurements started three months prior to the speed limit reduction and were continued for one year, a pre-measure and after-measure comparison of noise levels in comparable months was possible. Data on traffic volume and composition was available for the entire measurement period and it was found that the effect of differences in traffic volume and composition in the pre- and after-measure period on noise levels were small, (less than 0.3 dB) so no additional corrections for variations in traffic volume and composition have been made.

4 Results

Effect of speed reduction on nearby equivalent noise levels.

Fig. 3a-3d show the measured monthly averaged equivalent noise levels.

The speed limit reduction effect appeared to be rather limited. In The Hague and Rotterdam a reduction of 1.5 and 1.0 dB was found. In Amsterdam and Utrecht the effect was less: 0.5 and 0.1 dB. In Amsterdam, traffic analysis showed that due to congestion, the pre-measure average speeds were already approaching 80 km/h. In Utrecht, the speed reduction was limited to 80 km/h on the outer lanes only, while on the inner lanes the reduction was from 120 to 100 km/h.

Effect of speed reduction on nearby maximum noise levels.

Fig. 4a-4d show the monthly averaged hourly LAmax levels..

The speed reduction effect on peak levels in The Hague and Rotterdam was 2.5 and 2 dB. However, in Amsterdam and Utrecht a smaller reduction was found for the same reasons mentioned at the previous section.

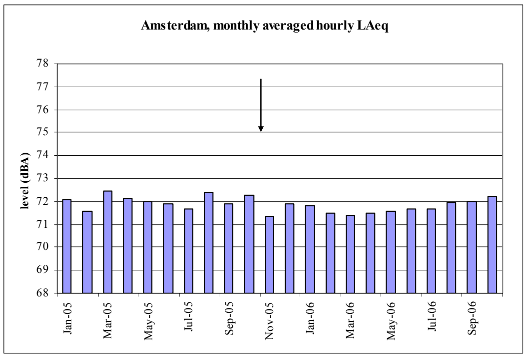

Fig.3a

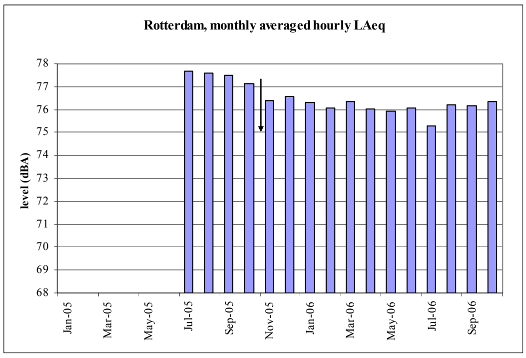

Fig.3b

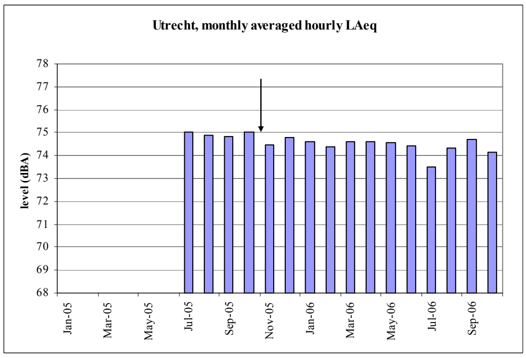

Fig.3c

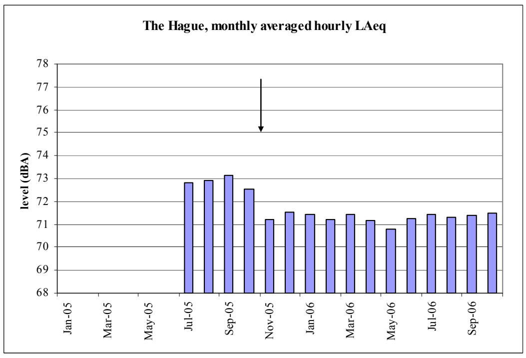

Fig.3d

[1] An approximate linear correction was applied for temperatures in between 8-25 °C, based on -0.1 dB/°C. Hours with temperatures above 25 °C were excluded, as the correction here is no longer valid

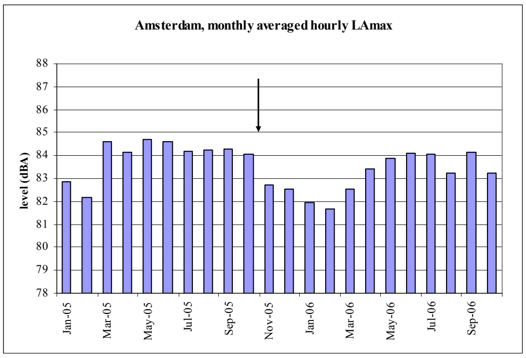

Fig 4a

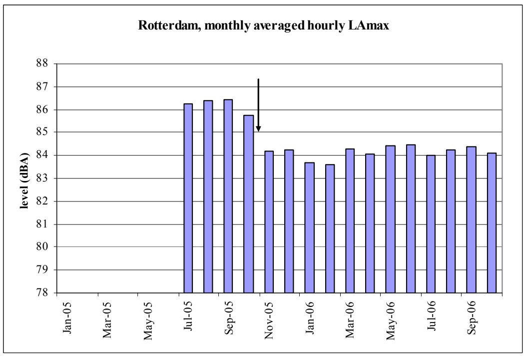

Fig.4b

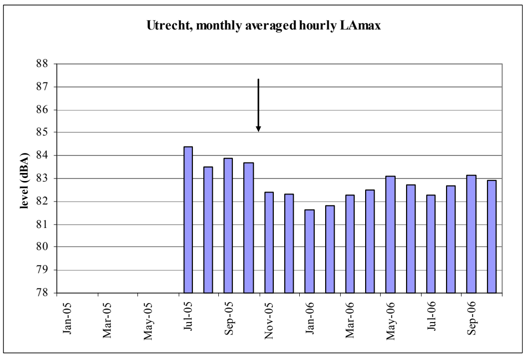

Fig.4c

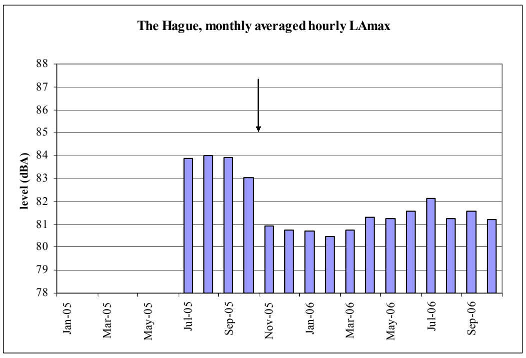

Fig.4d

Remarkably, the hourly averaged maximum noise levels appeared to be more affected than the equivalent noise level. We think this is most likely due to the fact that the reduced speed results in a more uniform traffic stream with smaller variations in noise emissions. The hourly averaged maximum noise levels have no judicial meaning in the Dutch road noise regulations. They can be important however in the way traffic noise is perceived and how annoyance is triggered.

5 Noise maps

The speed limit reduction effects shown are related to the noise emission of the particular road section. As the distance to the road increases, the reduction effect will decrease due to the influence of other road sections. Only the occupants of houses in the immediate vicinity of the road section will experience the noise level reduction.

The modelled effect of a speed limit reduction around the road segment involved is shown in fig.5a and 5b.

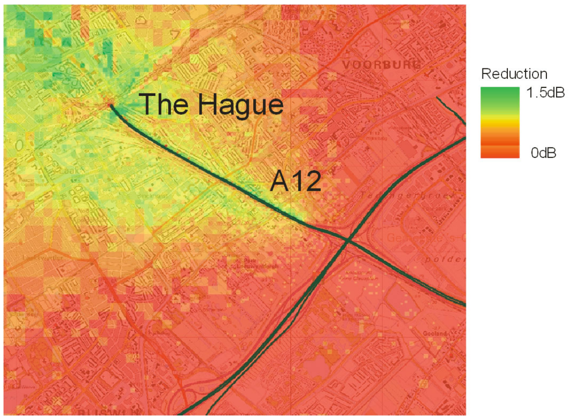

Fig. 5a

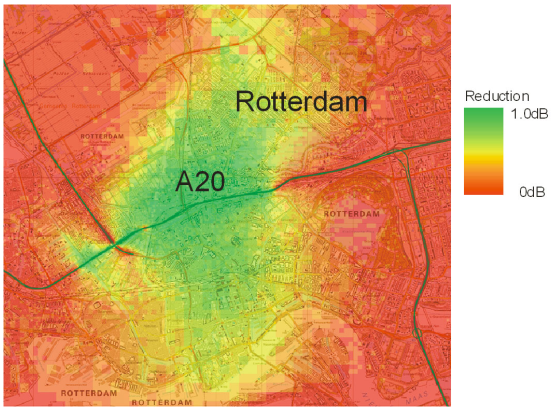

Fig.5b

In fig.5a, the The Hague results show that a speed limit reduction on the A12 motorway has a noticeable effect, but this is partly negated due to the unchanged situation on the A4 motorway nearby, especially in the NW and SE part of the map.

In fig.5b, a similar situation is shown for the Rotterdam area, where nearby segments of the A13, A16 and A20 (segments without speed limit reduction) partly negate the effect of the A20 road segment with a speed limit reduction.

For The Hague and Rotterdam, the benefits of a speed limit reduction could be made larger if the reduction were to be implemented on all nearby motorway segments.

6 Annoyance

A well known dose-response curve for road traffic noise levels and (high) annoyance is given by Miedema[2]. Fig 6a shows the percentage of the population which is severely annoyed depending on the noise level.

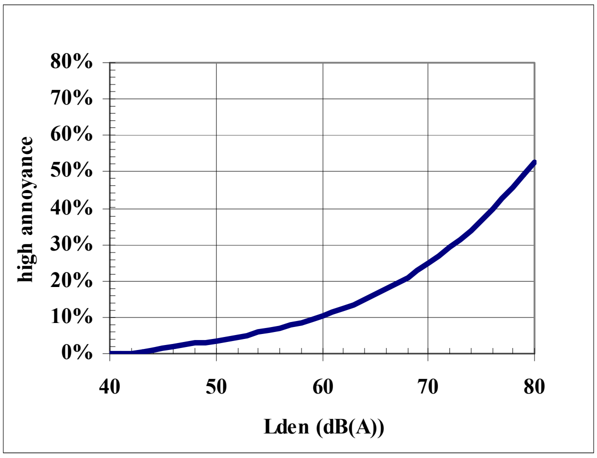

Fig 6a

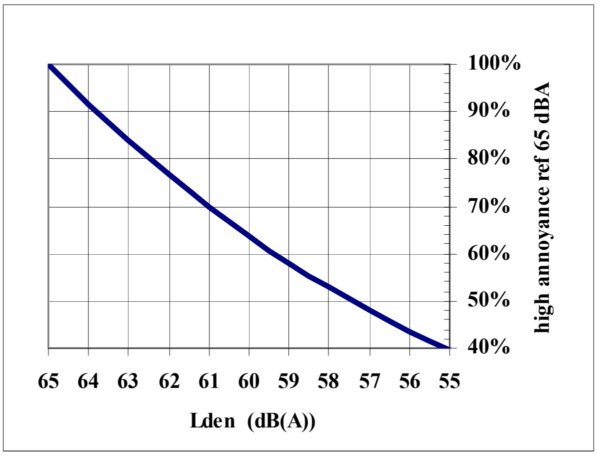

Fig 6b

Fig 6b is derived from Fig. 6a, and shows the effect of a reduction in noise level on annoyance. Starting with a noise level of 65 dBA, a reduction of 1 dBA will not result in more than 8 % reduction of the number of people who are severely annoyed. Approximately the same reduction will be achieved for a starting level of 70 or 80 dBA.

Theoretical relations of annoyance vs. noise levels however do not tell the complete story of annoyance in the neighbourhood of a busy motorway. The effect of a reduction in road traffic peak noise levels is not well known. It is possible that a more evenly distributed soundscape (less pronounced noise peaks) will be seen (heard) as a more favourable acoustical situation[3]. Future research in this field could use pre/post questionnaires in situations where a speed reduction is planned.

Even then, the possible positive effects of a reduction in peak noise levels are very local as the difference between LAmax and LAeq diminish rapidly with an increase in distance to a road.

7 A surprise

After this project was concluded in 2006, it was decided to maintain the monitoring location in The Hague to determine the effect of the degradation of the very-open asphalt-concrete that was laid on some of the A12 lanes in 2005. Much to our surprise however, the motorway authority decided to completely renew approx. 1 km of road directly alongside the monitoring position. It later appeared that this was already promised to the neighbourhood in 2005. The road section was repaved with a double-layer very-open asphalt concrete in September 2007. The effect on noise levels as measured is shown in fig.7

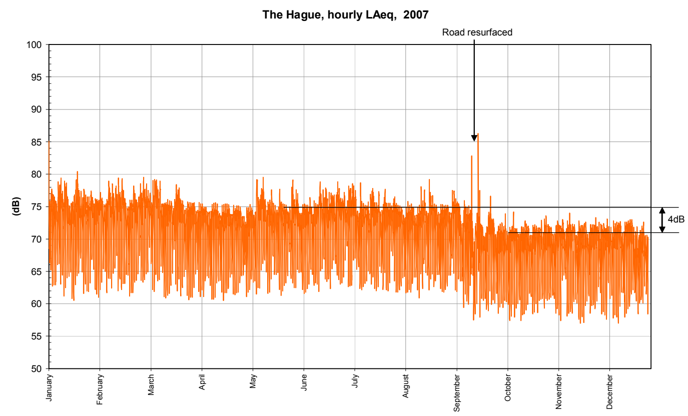

Fig 7

Comparing one month before and after the repaving, the reduction in LAeq noise levels is approx. 4 dBA. This will be further investigated in the next years. In particular it will be interesting to observe whether and how long the current noise reduction of the new pavement will be sustaine

8 Conclusions

- From July 2005 to October 2006 a reduction in noise level of 1.0-1.5 dBA, due to a speed limit reduction, has been measured in Rotterdam and The Hague. The effect in Amsterdam and Utrecht was much less, approx. 0.5 dBA.
- The effect on LAmax is more pronounced, in Rotterdam and The Hague 2.0 and 2.5 dBA, in Amsterdam and Utrecht 1.0 and 1.3 dBA.
- The measured effect in Utrecht is less because the speed reduction was implemented on the outer motorway lanes only.
- In Amsterdam the effect is less because traffic speed was already approaching the reduced speed limit due to congestion.
- A reduction in noise levels as seen in Rotterdam and The Hague could result in a reduction in the number of people who are severely annoyed of 8%. A more detailed investigation in similar situations would need to involve pre/post questionnaires.

- Resurfacing a road using a silent pavement (porous with optimized texture) show that this is more effective in terms of reduction of average noise emissions than a speed reduction measure. However, speed reduction yields additional benefits in the form of steady traffic flow, reduction of peak levels and relatively low implementation costs

References

[1] RIVM, rapport 680300001/2006, *Geluidmonitor 2005*, Bilthoven 2006

[2] Miedema H.M.E., Oudshoorn C.G.M., *Annoyance from Transportation Noise*, Environmental Health Perspectives 2001;109:409-416

[3] Robinson, D.W., *Towards a unified system of noise assessment*, Journal of Sound&Vibration 1971, 14(3) 279-298