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HOW CAN A CITY LIKE AMSTERDAM MEET THE *WHO* GUIDELINES FOR NOISE?

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Amsterdam is a vibrant city. But that also means that many residents may be highly annoyed by environmental noise. Excessive environmental noise is limited by legal noise standards, but even at low noise levels there can be annoyance and other health implications. That is why the World Health Organization (WHO) recommends strict guideline values for noise: 53 dB L_{den} and 45 dB L_{night} for road traffic, 54 dB L_{den} and 44 dB L_{night} for rail traffic. These guidelines values, which are significantly lower than the legal noise limits in the Netherlands, are *not* mandatory and are therefore not binding for Amsterdam or any other municipality. Nevertheless, it would be interesting to understand the implications of the WHO recommendations for Amsterdam and other municipalities. Therefore it is first investigated how many residents are subject to higher noise levels than these guideline values. It turns out that the noise from traffic on municipal roads is the main source of environmental noise in Amsterdam. The effect on the number of exceedances of the guideline values was then calculated for various measures. These measures are: zero-emission traffic, speed reduction, quiet road pavements, quiet tyres, noise barriers, quiet façades. Finally, it was determined which combinations of measures would achieve the guideline values among as many residents as possible. The most effective combination is: speed reduction, 100% zero-emission traffic, 100% quiet tyres. With this combination of measures, the percentage of Amsterdam residents for whom 53 dB L_{den} is exceeded by municipal road traffic near their homes decreases significantly. Mitigation measures are also possible for trams, trains and motorways, but because the number of residents affected is (much) smaller, these measures yield relatively much less than for municipal roads. The technical, financial and administrative preconditions for the implementation of such measures are not part of this study.

Keywords: WHO guidelines, environmental noise, mitigation measures

1. Introduction

The World Health Organization (WHO) has developed guidelines in 2018, providing recommendations for protecting human health from exposure to environmental noise [1]. The guideline values are:

- 53 dB L_{den} and 45 dB L_{night} for road traffic noise;
- 54 dB L_{den} and 44 dB L_{night} for railway noise.

It is important to emphasise that these guidelines have no legal status whatsoever in the Netherlands. The WHO guidelines are based solely on the health effects of noise, while the legal noise limits in the Netherlands also take into account social, technical and economic factors. The WHO guidelines are

therefore not binding for the Amsterdam city council. However, it is still good to have insight into the meaning of the WHO guidelines for Amsterdam and other municipalities.

The measures needed to implement such strict noise target values for the city of Amsterdam are assessed for road and rail traffic. To this end, the effects of scenarios that reduce noise to a greater or lesser extent are explored. In addition, it is discussed what would be needed to achieve a situation in which the WHO values are met for all dwellings.

Approximately 0.9 million people live within the borders of the municipality of Amsterdam (Fig. 1). The sources of environmental noise are traffic on municipal roads, trams, railways, motorways, aviation and industry. The scope of this assessment is limited to road traffic, trams and railways. For these source types, the effect of noise mitigation measures in terms of L_{den} is examined with a noise computation model of the city. The effect on L_{night} is not investigated, as L_{night} is not part of the Dutch noise legislation for these source types (apart from European obligations for the Environmental Noise Directive). Besides this, L_{night} is highly correlated with L_{den} for the source types under investigation.

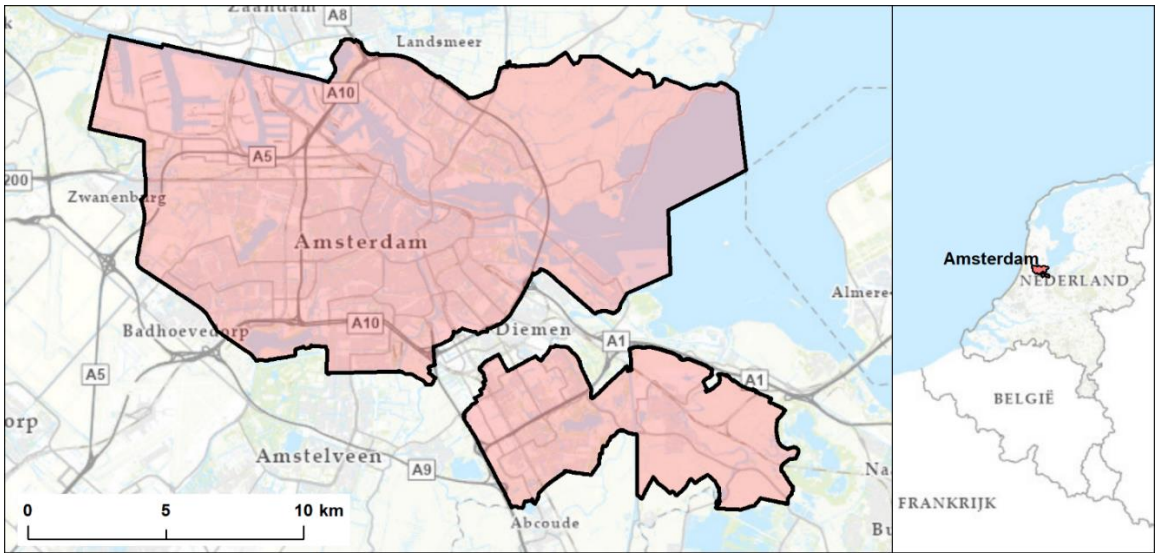

Figure 1: The municipality of Amsterdam.

2. Reference situation and scenarios

A reference situation has been defined for road, tram and railway noise. In addition, 7 scenarios with measures aimed at reducing noise exposure have been developed.

2.1 Reference situation

The reference noise situation is defined as follows:

- For municipal roads, the Amsterdam traffic model of 2030 was used for the traffic intensities. A recent speed reduction from 50 to 30 km/h in a large part of the city has already been included in this reference situation. The road surfaces in this situation are the present ones.
- Source data from the legal national noise register were used for national railways and national motorways. This legal register contains a so-called ‘noise emission ceiling’ rather than the current noise emission of these motorways and railways. In practice, the current noise emission will be lower than ceiling noise emission.

When we look at the numbers of people exposed to noise above WHO guideline values, municipal roads are the most important sources of noise. The left-hand graph of Fig. 2 shows per source type the percentage of dwellings with noise exposure above the WHO value (53 dB L_{den} for road, 54 dB L_{den} for rail). About 22% of all Amsterdam residents are exposed to noise from municipal roads above 53 dB L_{den}. If the noise from all roads (including trams) is added up acoustically, the noise exposure of 27,8% of all Amsterdam dwellings is higher than the WHO value. For rail traffic this is 4,7%.

Without the speed reduction that was implemented on December 8th, 2023, the percentage of dwellings above the WHO values would have been 32,2% instead of 27,8%. This already shows the effectiveness of a speed reduction.

The right-hand graph gives the noise distribution for municipal roads, expressed in numbers of dwellings per 'dB class'. In total, there are 493 000 dwellings in Amsterdam. The number of dwellings for low dB classes is underestimated as the traffic model does not contain roads with very low traffic intensities.

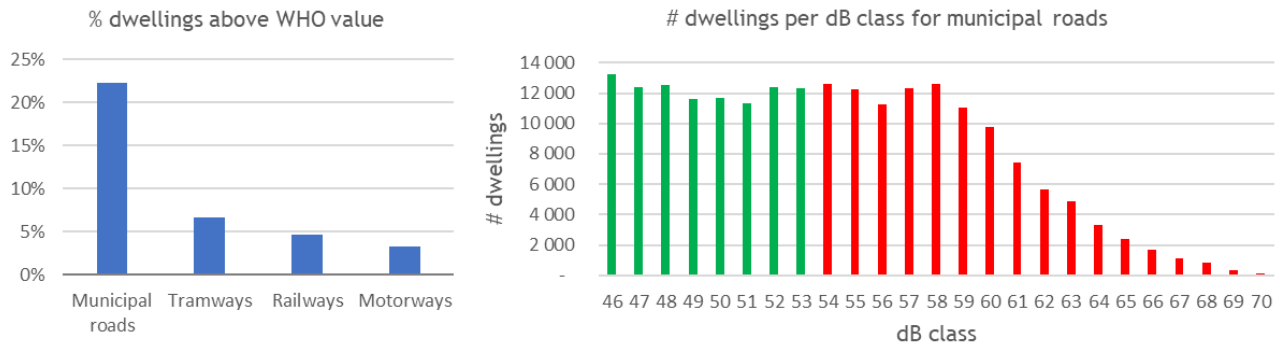

Figure 2: Left: noise exposure above the WHO value for L_{den}. Right: Noise distribution for municipal roads.

2.2 Scenarios

To reduce the number of exceedances of the WHO values, the effect of a number of scenarios with noise mitigation measures has been calculated. This exercise is presented here as an exploration of possibilities and these scenarios represent *possible* mitigation strategies. For most of these scenarios, the financial, technical or administrative limitations are not yet considered. These scenarios therefore do not represent the current noise policy of the Amsterdam city council.

Scenario 1: 30% Zero-emission traffic – The road traffic noise consists of tyre-road noise and engine noise. If all traffic is zero-emission, only tyre-road noise remains. In this scenario, it is assumed that on municipal roads 30% of the light vehicles is zero-emission, and also 100% of the medium and heavy vehicles. Furthermore it is assumed that on motorways 30% of the light, medium and heavy vehicles is zero-emission. This results in a noise reduction of 1.6 dB for municipal roads and 0.6 dB for motorways in the model. This scenario is based on the Amsterdam zero-emission traffic policy for 2030 and is considered quite realistic.

Scenario 2: Speed reduction – On many municipal roads the speed limit has already been reduced to 30 km/h in the reference situation. In Scenario 2 also the speed for the remaining municipal roads with 50 km/h will reduced to 30 km/h. For motorways, the maximum speed has been reduced to 80 km/h if it was 100 km/h in the reference situation.

Scenario 3: Quiet road surfaces – For this scenario, all road surfaces with brick pavers in the model have been replaced by silent brick pavers. This results in a local emission reduction of 1.5 to 2.0 dB. It was not decided to replace dense asphaltic concrete with acoustically optimized asphalt, because on many locations there are technical limitations.

Scenario 4: Quiet tyres – If quiet tyres are applied, it is assumed that the tyre-road noise reduces by 5 dB, while the engine noise is not affected. This measure yields 3 dB reduction on municipal roads and 2,3 dB on motorways.

Scenario 5: Quiet tramways – Rolling noise of trams is caused by the roughness of rails and wheels. In this scenario it is assumed that rolling noise can be lowered by 2 dB as a result of rail roughness reduction (e.g. rail grinding).

Scenario 6: Noise barriers – In this scenario high noise barriers are built along all railways (5 m high) and all motorways (8 m high). This also incorporates a few major inner city roads where barriers are a feasible measure.

Scenario 7: Quiet façades – Inside dwellings with at least one quiet side, noise annoyance can expected to be lower than in dwellings without a quiet side. In the model this advantage is incorporated by a conditional noise reduction of 2 dB, to be subtracted from the façade with the highest exposure level if the cumulative noise on that façade is above 52 dB while on at least one other façade it is less than 52 dB. This measure is intended to be an estimate of the improvement of environmental quality rather than a noise reduction measure.

2.3 Results

The results of the calculations are shown in Table 1. The noise caused by trams is included in road traffic.

Table 1: Percentage of Amsterdam dwellings above the WHO value for all scenarios.

Scenario	Roads	Railways
0: Reference	27,8%	4,7%
1: 30% Zero-emission traffic	24,3%	4,7%
2: Speed reduction	23,0%	4,7%
3: Quiet road surfaces	27,3%	4,7%
4: Quiet tyres	20,9%	4,7%
5: Quiet tramways	27,3%	4,7%
6: Noise barriers	25,3%	0,4%
7: Quiet façades	26,4%	4,4%

This assessment shows that none of the scenarios is sufficient to reduce the noise below the WHO values. Adjustments to the infrastructure (road surfaces, tramways) result in a local noise reduction, but on the scale of the whole city the effect is small. This is also true for noise barriers. Generic measures such as quiet tyres and speed reduction have the most effect. 30% Zero-emission traffic also has a significant effect.

3. Combination of scenarios

3.1 Description

The results shown in Section 2.3 demonstrate that it is not possible to meet or even approach the WHO value with individual measures. This section shows what reduction is possible with combined generic

measures (i.e. measures that are not just locally effective). This involves the combined effect of a largely zero-emission car fleet with quiet tyres. Also, this section provides an overview of what additional measures are needed to achieve the WHO value. The scenarios considered are:

Scenario A: 30% Zero-emission traffic and Quiet tyres – This is a combination of scenario 1 and 4. The noise reduction on most municipal roads is calculated to be 5.1 dB.

Scenario B: 100% Zero-emission traffic and Quiet tyres – This is a also combination of scenario 1 and 4, but in this case all traffic is zero-emission (referred to as scenario 1'). The noise reduction on most municipal roads is calculated to be 7.5 dB.

These scenarios only indicate the technical possibilities. It is emphasized that measures such as (100%) Zero-emission and the full implementation of Quiet tires will require an enormous effort, the feasibility of which is still uncertain.

3.2 Results

In Section 2.1 it was shown that municipal roads are the main noise source in this study. Therefore the results of a combination of measures are only presented for municipal roads. As scenario 5 (Quiet tramways) has no effect on the noise from car traffic, this scenario is not shown here. Table 2 gives an overview of the results for municipal roads.

Table 2: Percentage of Amsterdam dwellings above the WHO value (53 dB L_{den}), for municipal roads.

Scenario	Municipal roads
0: Reference	22,2%
1: 30% Zero-emission traffic	18,1%
2: Speed reduction	17,8%
3: Quiet road surfaces	21,6%
4: Quiet tyres	14,9%
6: Noise barriers	22,1%
7: Quiet façades	20,9%
A: 1 + 4	9,9%
B: 1'+ 4	4,9%

It can be seen that the combinations made in scenario A and B have a considerable combined effect.

4. Discussion

The generic measures of scenario 1 and 4 lead to a noise reduction on almost all roads. Still, some of these roads would require further measures if the aim is a situation with no dwellings above the WHO value. Because it is unfeasible to ban road traffic from *all* municipal roads, we looked at a potential 'target situation' in which only 5 500 dwellings are above the WHO value. This number corresponds to 5% of the number of dwellings that exceed the WHO value in the reference situation (110 000 dwellings). To accomplish that target, a further 9 - 12 dB noise reduction would be necessary for scenario 1 through 7. For scenario A and B a further reduction of 7 dB and 5 dB, respectively, would be required.

The required (additional) noise reduction to achieve this potential target on municipal roads depends on each scenario, but it is considerate in most cases. Combining more scenarios will not be sufficient for that purpose. In addition, it will be unavoidable to strongly reduce traffic intensity, but this is considered hardly realistic. Note that 3 dB reduction requires halving the traffic intensity, and 10 dB means that only 10% of the traffic would remain.

5. Conclusion

Road traffic noise is the main source of environmental noise in Amsterdam. Calculations show that road traffic noise is higher than 50 dB L_{den} for about one third of the residents of Amsterdam. The noise from municipal roads is by far the most important noise source. Locally, trams, railways and motorways are also relevant noise sources that cause annoyance. Noise from aviation and industry is significant too, but these sources are not part of this assessment.

The WHO has made recommendations for the protection of human health from noise from roads and railways. It is recommended to reduce noise from road traffic to 53 dB L_{den}, and for rail traffic to 54 dB L_{den}. If the noise from all roads (including trams) is added up acoustically, the noise exposure of 27,8% of all Amsterdam dwellings is higher than the WHO value of 53 dB L_{den}. Without the large speed reduction programme that was implemented on December 8th, 2023, the percentage exceedances of the WHO values would have been 32,2% instead of 27,8%. For rail traffic the WHO value of 54 dB L_{den} is exceeded at 4,7% of all dwellings.

This study demonstrates that in order to considerably reduce the percentage of dwellings that are above the WHO values, ‘generic’ measures are more effective than local measures. The generic measures considered here are: Quiet tyres, Speed reduction, 30% Zero-emission traffic.

By combining the measures Quiet tyres and 30% Zero-emission traffic, the percentage of exceedances of the WHO value drop to 9,9% of all Amsterdam dwellings, or even 4,9% if *all* traffic becomes zero-emission. The measures Quiet tyres and Zero-emission for all vehicles will need an tremendous effort and these measures are not yet in reach of the Amsterdam city council. It is obvious that in order to comply with the WHO recommendations, rather large noise reductions are necessary. Combining more scenarios will not be sufficient. It will then be unavoidable to strongly reduce traffic intensity, but this is considered hardly realistic.

FUNDING

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REFERENCES

1 World Health Organization, *Environmental noise guidelines for the European Region*, (2018).