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# On the road to silent waste collection

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Waste collection is a significant noise source in a modern urban environment. To minimize the disturbance to the society, there is an increasing pressure to move the waste collection to the off-peak traffic hours of the day. To achieve this, as silent as possible ways to collect waste are required. A way to accomplish this is to use electrical trucks for waste collection. Simultaneously, the containers and the handling of containers must be made more silent than now. We are currently developing new concepts for electrical trucks, their compaction systems, as well as for the containers and their handling. As the first step, we have evaluated current situation with conventional trucks, containers, and waste collection methods in urban environment, by recording the noise and video of typical waste collection procedures. The most annoying noise comes from the impulsive noise sources, such as waste container transport on uneven surface, as well as from the waste container emptying to the waste collection truck. In addition to the expected lower inherent noise with electrical trucks, we have found out that significant decrease in noise levels and annoyance are possible in the handling of the waste containers.

## 1 Introduction

Waste collection with the related truck traffic and emptying of waste containers is a significant noise source in modern urban environment [1]. The outdoor noise is usually well regulated, as is the case for European Union [2], from where the statute is also derived to the Finnish legislation. To minimize the disturbance to the society, there is an increasing pressure to move the waste collection to the off-peak traffic hours of the day. To achieve this, as silent as possible ways to collect waste are required.

Noise in existing trucks cannot probably be much lowered. There have been several experiments with electrical trucks [3], [4] as well as comparisons between electrical and conventional trucks [5]. The use of electrical trucks may improve noise situation to a certain degree.

Simultaneously, the containers and their handling must be made more silent than they now are. There are regulations [2] and guidelines for the waste collection [6]. The regulations give quite exact methods how to measure the noise levels of waste handling and containers, in addition to the trucks.

We are currently developing new concepts for electrical trucks, their compaction systems, as well as for the mobile waste containers and their handling. As the first step, we have evaluated current situation with conventional trucks, containers, and waste collection methods in urban environment, by recording the noise and video of typical waste collection procedures, and analysing the results.


Figure 1. Waste containers under study

# 2 Measurements

To achieve the basic understanding of the current situation a measurement campaign was carried out. The study targets were 4 waste containers and also the operation of a diesel waste collection truck in waste collection. The measurements and data acquisition were carried out with a mobile HEAD acoustics SQobold recorder-analyser. 4 channels were used. Channels 1 & 2 were used for a binaural microphone (mic channel 1 = left, mic channel 2 = right), and channels 3 & 4 for free-field microphones. Additionally, simultaneous video was recorded as well as additional video and photographs were taken. The noise data was recorded as time series with sampling rate of 48 kHz, to facilitate versatile post-processing of signals.

## 2.1 Rolling noise measurements for waste containers

The containers under study are shown in Figure 1. There was some prior information of the possible noise levels of the containers available. All the containers were 600 l in volume, and had 4 wheels. The container 2 was estimated to be noisiest according to the prior observations. Container 3 was modified to be as silent as possible, and it had some wheel and structure modifications.

The noise measurement setups for the waste containers are shown in Figure 2. The setup 1 as at the left side of the figure and the setup 2 at the right side of the figure. The setups are physically located in the same area as shown in the figure, and only an acoustically transparent fence separates them (at the middle of the figure). The yard for the setup 1 was smooth, asphalt surface and for setup 2 rough, tiled surface.

In both cases the waste container were transported by pulling them from the waste canopy to the street and back. All the containers were empty during these measurements.

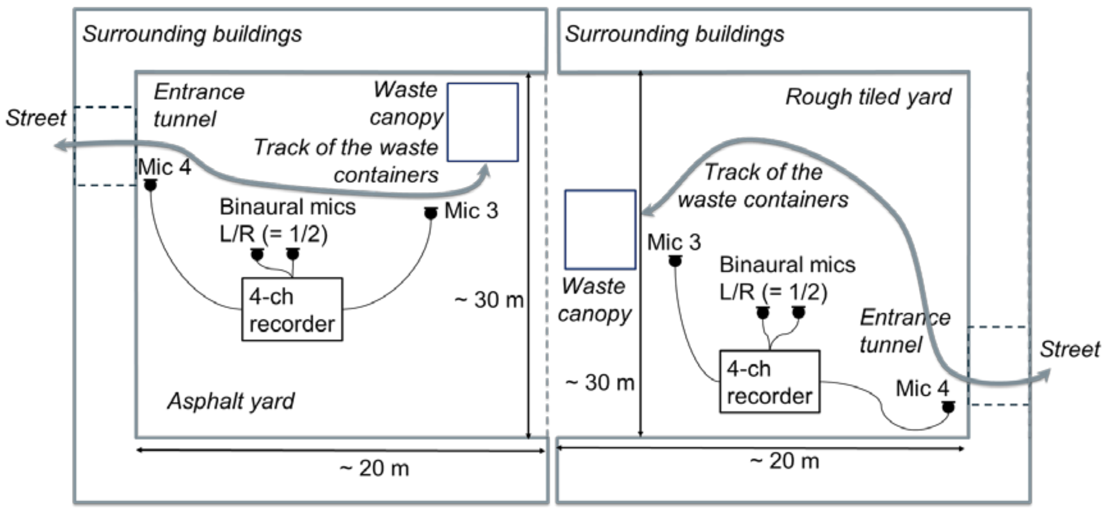


Figure 2. Measurement setups for the waste container rolling noise. On the left, case 1 and on the right, case 2.


Figure 3. Waste collection truck and the packer.

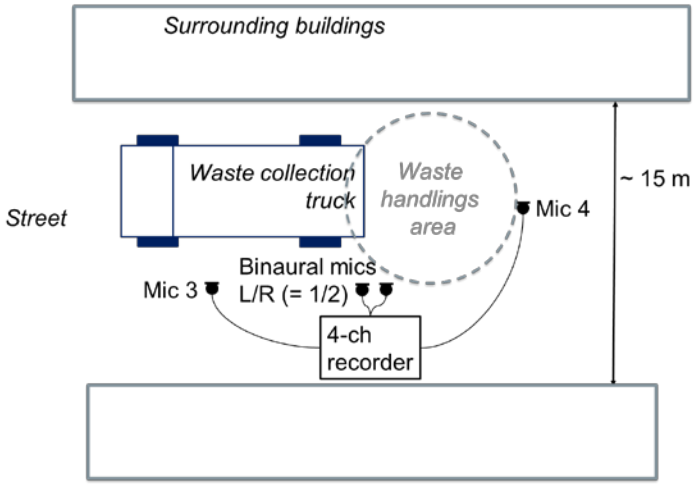


Figure 4. Measurement setups for the waste collection truck and waste container handling.

## 2.2 Noise measurements for the truck and handling of waste containers

The waste collection diesel truck was equipped with automated compaction system, shown in Figure 3. The location of measurement microphones and the actual waste handling area are in the Figure 4. In addition to the car, one of the main sources of the noise was the waste container hitting the limiter bar, as illustrated in Figure 5.


Figure 5. Impact noise is created when the waste container hits against the limiter bar.

# 3 Analysis of the noise measurements

The rolling transport noise levels of 4 containers are presented in Figure 6. The results are in line with the prior information. For the smooth asphalt surface (the left figure) container 3 is the least noisy with the averaged $L_{Aeq}$ value of 63.7 dB, and container 2 is the noisiest with the value of 67.3 dB. The difference is not large, only a bit over 3 dB and the actual annoyance should be judged by more detailed analyses. The values are calculated as an average of 3 moves of each container. The joint reference value for each container is calculated as an average of all microphone positions. On the rough, tiled surface (right figure) the differences are smaller but the overall levels are higher.

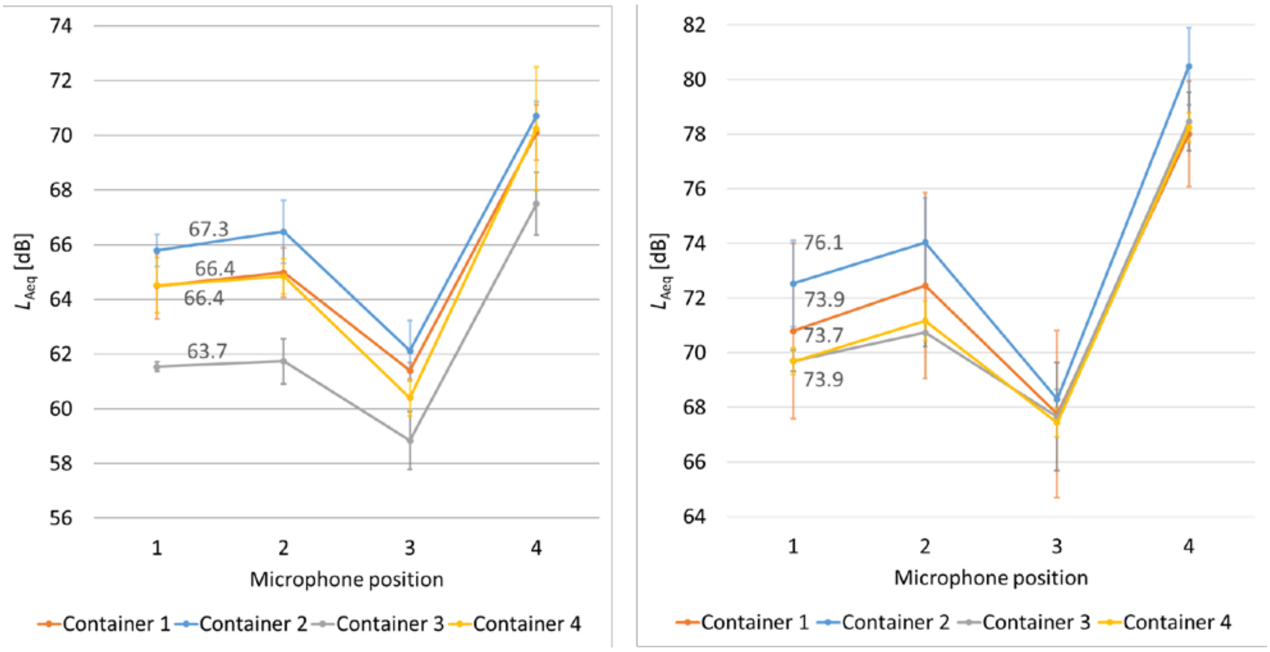


Figure 6. Rolling noise properties of four containers. Left side: smooth surface, right side: rough, tiled surface.

In Figure 7 the effect of manual deceleration of the waste bin lifting device is shown. Without manual braking the container hits against a limiter bar and creates high level impact noise. These results are acquired from the left ear of the binaural microphone. There were 4 different conditions: the container lid open or not and with or without the manual braking. The manual braking slows down the process somewhat, but also considerably reduces the noise.

The last apparent noise sources in the waste collection cycle are the engine and hydraulic pump noise. The engine speed is usually automatically increased to speed up the hydraulic pump and consequently the process of the container lifting and the operation of the garbage compaction system. To study this effect the compaction cycle was measured with a constant engine speed and automatically controlled engine speed. The cycle time was thus changed from 20.5 s to 24.5 s i.e. by 20 %. Respectively, the equivalent SPL was increased from 69 to 74.5 dB and the loudness from 25 to 40 sones.

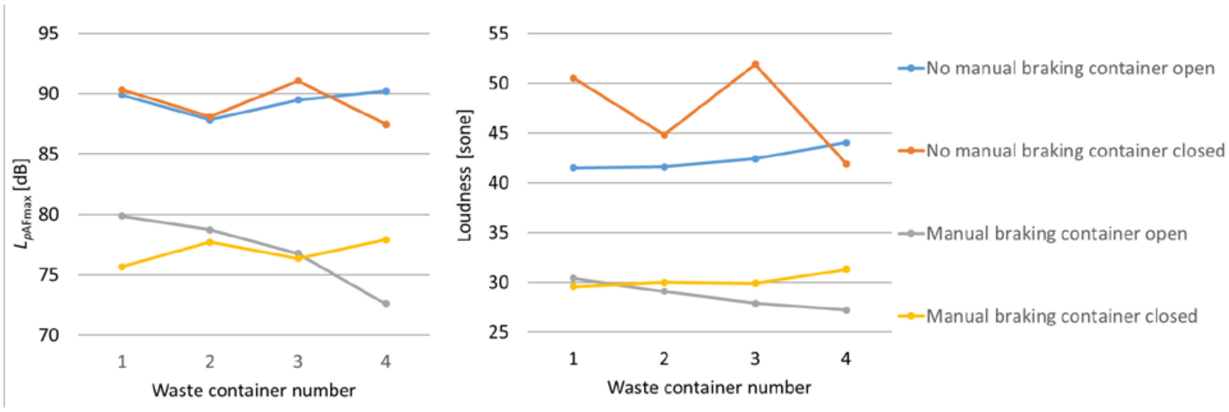


Figure 7. The effect of manual braking of the container lifting. Left: A-weighted maximum SPL, right: loudness.

# 4 Conclusions and future work

The most annoying noise comes from the impulsive noise sources, such as waste container rolling on uneven surface, as well as from the waste container emptying to the waste collection truck. The narrow band noise from the hydraulics is however perceptibly an annoying phenomenon the effect of which should be studied more.

In addition to the expected lower inherent noise with electrical trucks including the replacement of hydraulic actuators with electric ones, we have found out that significant decrease in noise levels and annoyance are possible in the handling of the waste containers.

# 5 Acknowledgements

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