Effects of Low Emission Zones (LEZ) on air quality in Germany

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Low Emission Zones (LEZs) were implemented as a measure for improving air quality of ambient air, especially in cities where the European limit values for PM_{10} (particulate matter with an aerodynamic diameter < 10 µm) were exceeded. By end of 2014 almost 50 LEZs were introduced in Germany.

In the framework of the ACCEPTED project (Assessment of changing conditions, environmental policies, time-activities, exposure and disease, www.acceptedera.eu/) we evaluated the effects of LEZs on the air quality in European cities. Here we present results for three German cities: Augsburg, Munich and Berlin. Table 1 compares the LEZs implemented in those cities. In general, the LEZs differ largely in size and implementation time from city to city.

Table 1: Comparison of German LEZs in Augsburg, Munich and Berlin.

	Augsburg	Munich	Berlin
LEZ area	~ 6 km^2	~ 44 km^2	~ 88 km^2
% of city area	3%	14%	10%
Heavy traffic ban	yes	yes	no

To assess the effectiveness of LEZ we used a general additive model following the approach described by Fensterer et al. (2014). The model was adjusted for PM_{10} levels at reference site (located in regional background), wind direction, public holidays, day of the week, and time of the day. Because of the seasonal variation in PM_{10} concentrations, we modelled LEZ and time effects for summer and winter separately by introducing of an indicator function.

Comparison of the effects for different seasons: we observed clear seasonal differences regarding the magnitude of the effect. The reduction of PM_{10} levels was in general more pronounced in summer season compared to winter season. In winter, additional particle sources (such as domestic heating, wood combustion, re-suspended dust due to the application of road salt for deicing) contribute significantly to the PM_{10} mass concentrations in the ambient air. In addition, the generation of secondary aerosols such as nitrate or sulphate is more intensive in winter. Consequently, exhaust particles represent a smaller fraction of the fine particles in winter than in summer. This could be the reason that measures regulating only the exhaust particles could became less effective in the winter period.

Comparison of the effects for different cities: the results for Augsburg were not consistent both regarding the differences between summer and winter seasons as well as between traffic sites and urban background site. On the contrary, a clear reduction of PM_{10} levels was observed in Munich and Berlin after implementation of LEZ in those cities. The magnitude of the reduction was larger for Berlin, the decrease of PM_{10} concentration in Berlin range between -6 and -19% depending on the monitoring site and the active stage of the LEZ.

Comparison of the effects for different particle metrics: in Berlin organic carbon (OC) and elemental carbon (EC) concentrations have been measured at major roads since the1990s. The decrease of total carbon (TC=OC+EC) concentrations was clearly larger than the corresponding decrease of PM_{10} levels. Whereas PM_{10} concentrations at a traffic site decreased after the implementation of the LEZ by 16% in summer and 9% in winter, the corresponding reduction of TC was 24% (summer season) and 16% (winter season).

Conclusions: in sufficiently large and strictly regulated LEZs a reduction of PM_{10} concentration between 5 and 10 % (at traffic site partially up to 20 %) can be expected. The reduction of PM_{10} levels is in general more pronounced for the summer season compared to the winter season. It means that LEZs are proving successful as a measure for air pollution control. Moreover, they decrease not only PM_{10} but, to a much higher degree, the health-relevant components (such as diesel soot) contained in PM_{10}. Therefore, the effect of LEZs on air quality could be much better estimated by additional monitoring of diesel soot and elemental carbon in PM_{10} and the benefit on human health is by far greater than it is presently visible from measurements of PM_{10}.

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