

Regional lung dose of submicron aerosol particles in urban background, roadside and rural atmospheres

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Estimates of respiratory deposition dose can play a vital role in assessing health effects from exposure to airborne particles. However, there are few studies that estimate the lung doses of submicron particles in the human respiratory tract. Therefore, the aim of this study was to calculate regional lung dose of submicron aerosol particles in three different environments, including urban background, roadside and rural areas.

Particle number size distributions were measured by a Scanning Mobility Particle Sizer (TSI, USA), covering the size range 16.5-604 nm operated by the Department for Environment, Food and Rural Affairs (DEFRA). In this study, a year of data measured at a roadside site (Marylebone Road), an urban background site (North Kensington) and a rural monitoring site (Harwell) during 2008 were extracted from the DEFRA website.

From the data obtained, both the total and regional lung doses of concentration metrics were calculated using the ICRP model (International Commission on Radiological Protection, 1993) based on Hind's (1999) parameterization (Elihn et al., 2011). The total deposition fraction of submicron particles in the human respiratory tract were 0.49, 0.45 and 0.43 at Marylebone Road, North Kensington and Harwell, respectively. The hourly average number, surface and volume doses at the roadside were 16.9×10^9 particles, 1.5 cm^2 and $3.8 \times 10^6 \mu\text{m}^3$. The total hourly deposited dose based on the number metric at the roadside site was 3.4 and 7.7 times higher than those at urban background and rural sampling sites.

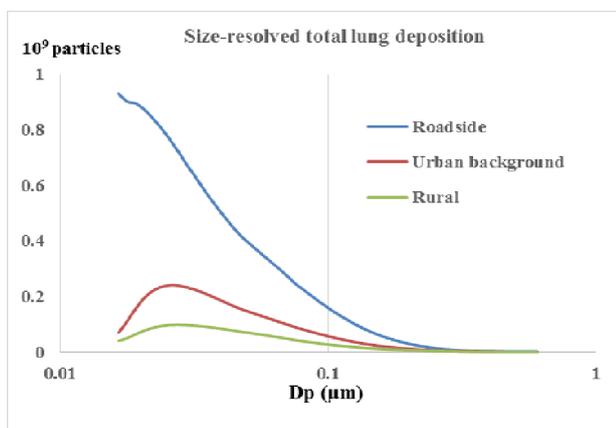


Figure 1. Size distribution of total hourly number doses

Ultrafine particles ($D_p < 100 \text{ nm}$) represented more than 93.3% of total deposited particle number (see Figure 1), while they accounted for 15-20 % of total deposited particle volume. In terms of regional deposited dose, the largest fraction of deposited particles for all metrics was found in the alveolar region as shown in Table 1. The coefficient of determination (r^2) between hourly lung dose and hourly PM_{10} and $\text{PM}_{2.5}$ was also investigated, suggesting that the PM mass metrics can be a good predictive estimate of surface or volume dose in some environments. However, they show a weak relationship with particle number dose.

Table 1. Percentage of total deposited particles (%) in extra-thoracic (ET), tracheo-bronchial (TB), and alveolar (AL) regions.

Site	Region	Number	Surface	Volume
Roadside	ET	11.7	19.8	33.3
	TB	19.2	12.8	8.4
	AL	69.1	67.3	58.3
Urban Background	ET	11.2	20.4	32.6
	TB	18.3	12.3	8.2
	AL	70.5	67.3	59.2
Rural	ET	11.4	23.0	35.0
	TB	18.0	11.4	7.5
	AL	70.6	65.7	57.5

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