Lung-Deposited Surface Area

A new metric for measuring ultrafine particles

What is LDSA?

- Lung Deposited Surface Area (LDSA) refers to the surface area of airborne ultrafine particles (UFPs) that deposit in the human respiratory tract, typically expressed in $\mu m^2/cm^3$ of air inhaled.
- Conventional air quality metrics like PM_{10} and $PM_{2.5}$ measure particle mass but overlook UFPs, therefore underestimating actual exposure, especially from pollution sources like traffic and combustion sources, wood burning, and airports.
- LDSA can be measured using compact, low-maintenance sensors using diffusion charging, enabling high-resolution, long-term monitoring.

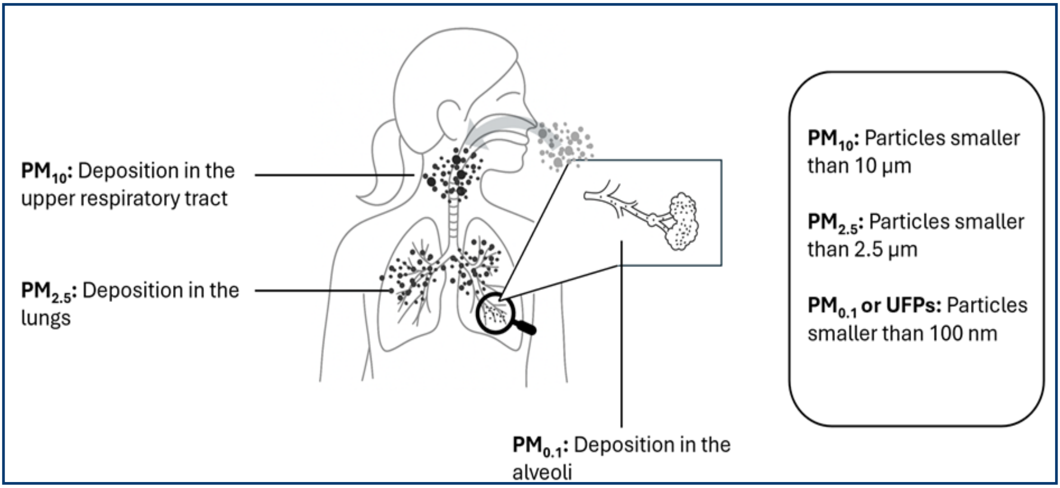
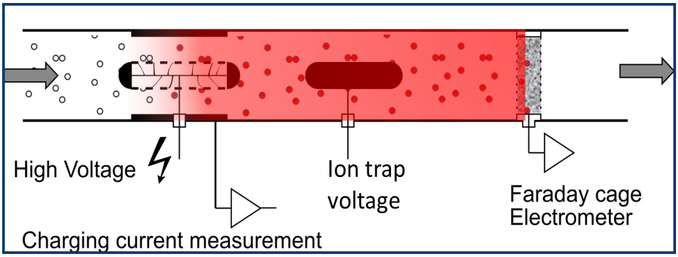


Figure 1. Schematic of particle deposition in the human respiratory system.

Lung deposition: When we inhale, large particles (PM_{10}) get trapped in the upper respiratory tract, while smaller particles ($PM_{2.5}$) can be transported deeper into the lungs. UFPs can reach the alveolar region where the particle surfaces interact directly with lung tissue, even crossing into the bloodstream, potentially causing inflammation and contributing to various pulmonary and cardiovascular diseases (Figure 1).[1]

Particle surface: For insoluble particles, the particle surface is the initial point of contact for interactions with its surroundings, including biological tissue. This means that the human body comes into direct contact with potentially toxic or carcinogenic substances adsorbed onto the particle surface. The larger the total surface area of these lung-deposited particles (LDSA), the higher the potential health risk.[2]



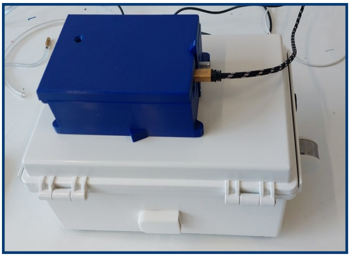


Figure 2. (left) the diffusion charging method, (right) the LDSA sensor used in Net4Cities.

Measuring LDSA: In Net4Cities, we use compact, low-maintenance diffusion-charging sensors developed by *naneos particle solutions GmbH* (Figure 2). In this method, particles become electrically charged as they pass through a charging region. The induced current from these charged particles is approximately proportional to their LDSA. This stable, lower-cost method enables long-term monitoring with high temporal resolution.[3,4]

LDSA vs. traditional metrics: Imagine placing a bag filled with marbles (PM_{10}) on a scale. Even with comparatively few marbles, the bag is already quite heavy. Adding a spoonful of rice ($PM_{2.5}$), slightly increases both the weight and the number of particles. Finally, introducing a spoonful of flour (UFPs) barely affects the total weight, but the number of particles rises exponentially.

By adding LDSA to traditional mass metrics (i.e., PM_{10}), we gain a more complete view of health risks associated with ultrafine particle pollution that weight-based measurements fail to capture.

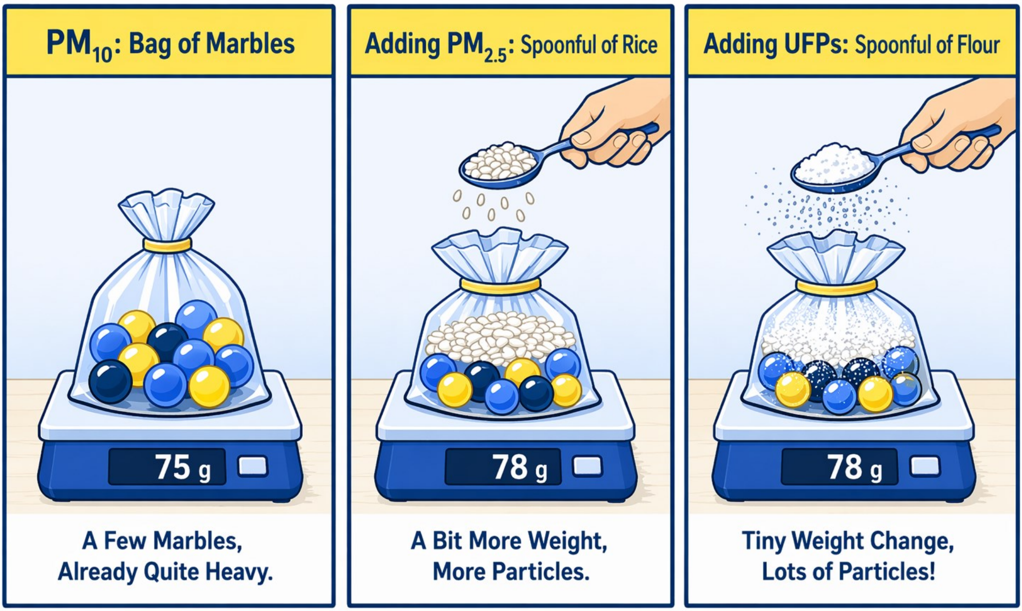


Figure 3. While not to scale, this scenario illustrates why UFPs are underrepresented in mass based metrics conceptually (i.e., PM_{10}).

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(2) Oberdorster, G. Significance of Particle Parameters in the Evaluation of Exposure-Dose-Response Relationships of Inhaled Particles. *Inhal. Toxicol*. 1996, 8 Suppl, 73–89.
(3) naneos - miniature nanoparticle detectors made in Switzerland. https://www.naneos.ch/
(4) Fierz, M.; Meier, D.; Steigmeier, P.; Burtscher, H. Aerosol Measurement by Induced Currents. *Aerosol Sci. Technol.* 2014, 48 (4), 350–357.

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(Figure 3) - Produced with the help of ChatGPT

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