Lung Deposition of Airborne Particles – Resolved in a Single Breath

There are numerous urban sources releasing particles into the air we breathe every day. Exposure to air pollutants and particulate matter has been listed as a key health issue, leading to cardiovascular and respiratory disease as well as cancer. The health effects partly depend on which type of particles that we are exposed to, but also how sensitive we are as individuals. In this thesis, a set-up was built for studying the airborne particles in the breathing zone, with time resolution in each breath. This type of set-up allows for studies of the total deposition of airborne particles and for investigating at what lung-depth the particles get caught.

By understanding how the airborne particles in our surroundings deposit in our lungs, we will be able to understand how the exposure of airborne particles affects our health. It is only the fraction of particles that get caught in the lungs that will give rise to the negative health effects. The outdoor air quality depends heavily on where we are situated. In a city, there are many particle sources, whereas in the countryside there are fewer. On an individual level, the sensitivity to air pollutants and airborne particles is determined by the individual variance in how these particles get caught in our lungs. It has been shown in previous studies that the deposition often varies from individual to individual. Because of these individual differences, it is important to study both how many particles that deposit in the lungs, but also where they get caught.

Deposition in the human respiratory tract has been researched for over a decade at the aerosol-group at LTH with various studies and measurements. The next step is to study the deposition online, within a single breath. Such a set-up would facilitate for a faster collection of lung deposition data from different groups of individuals (i.e. diseased, healthy, old, young, man, woman etc.) without posing any health risk itself.

In the present thesis, conducted at Lund University, a set-up was built for studying the airborne particles in the breathing zone, with time resolution in each breath. The set-up consists of three main modules, i.e. an aerosol generation module, an inhalation system and a particle detection unit.

The Set-up, see Figure 1, was designed to minimize losses and allow for spontaneous breathing through the mouth. A monodisperse aerosol is generated continuously. The aerosol is pumped into the inhalation tank and travels through a duck-valve which will open during inhalation and close during exhalation. A pneumotachograph is placed after the duck-valve to measure the flow of aerosol during both inhalation and exhalation. The inhaled aerosol travel through a heated area, the breathing zone. The breathing zone of the set-up was connected through 3D-printed tubings designed in SolidWorks which had been sprayed with metal spray on the inside.

A fast measurement device for measuring the particle concentration (a condensation particle counter) was used to characterize the final set-up. First by inducing abrupt flow changes and second by using a so-called “artificial lung”, essentially a motor-driven cylinder capable of simulating a human adult breathing flow pattern. The fast condensation particle counter showed a proof of concept with respect to the time resolution requirements as it could sample 10 times each second. However, there were fluctuations in the sample flow entering the fast device and thus a more robust and reliable instrument with high time resolution would be needed before using the suggested set-up in real lung deposition studies.

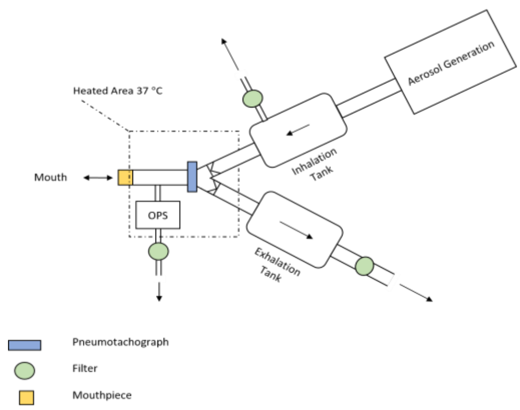

Figure 1. Schematic drawing of the final set-up.

Popular scientific summary of the master’s thesis Lung Deposition of Airborne Particles – Resolved in a Single Breath. *Amalia Larsson Hurtig, 2020.*