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Three dimensional modeling of air flow, aerosol distribution and aerosol samplers for unsteady conditions

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Abstract

Despite the importance and wide use of aerosol samplers, their basic characteristics including gas flow dynamics, sampling, and aspiration efficiency are still not fully understood and characterized. This is especially the case when a personal inhalable sampler operates under conditions of calm or slowly moving air. Under such conditions, the results may be affected by the breathing of the person. The development of the next generation of sampling devices should be facilitated by the improved knowledge derived from mathematical studies of particle motion in the complex flows around bluff bodies where aspiration occurs. In this work, a three-dimensional and time dependent model of aerosol sampling is developed that can be applied to any feasible aspiration situation. Direct accounting for all the three spatial coordinates and temporal dependence makes the model four dimensional. In order to investigate aspiration characteristics when a sampler is fixed on a person, a digital model of a person is developed. The "digital mannequin" can breathe through the mouth or nose and is heated to body temperature to account for convection effects of warm air around the body. The developed model allows simulation of nonstationary air flow and aerosol particles dynamics around any bluff body in both indoor and outdoor conditions. The gas flow and aerosol particles dynamics around a breathing person at the conditions of calm or slowly air moving are computed for both mouth and nasal breathing. It is shown that in such a situation the aspiration efficiency is place and time sensitive. Temporal dependences of aspiration efficiency are computed and averaged characteristics are derived. © The Royal Society of Chemistry.

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