Measuring Occupational Dust Exposure with a Passive Sampler

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Akademisk avhandling

som med vederbörligt tillstånd av Rektor vid Umeå universitet för avläggande av teknologie doktorsexamen framläggs till offentligt försvar i Triple Helix, Samverkanshuset, fredagen den 13 april, kl. 09:00. Avhandlingen kommer att försvaras på engelska.

Fakultetsopponent: Professor, Christer Johansson, Institutionen för miljövetenskap och analytisk kemi, Naturvetenskapliga fakulteten, Stockholms universitet, Stockholm, Sverige.

Public Health and Clinical Medicine
Occupational and Environmental Medicine
Abstract

Objectives: In a working environment it is important to measure dust exposure to evaluate possible health issues. Passive sampling could be an alternative to active sampling with pumps when measuring occupational dust exposure. One passive sampler is the University of North Carolina passive aerosol sampler (UNC sampler). Promising results for the applicability of this type of passive sampler have been shown for particles above 2.5 µm, but indicate large underestimations for PM$_{2.5}$. The overall purpose was to develop more knowledge about the UNC sampler and the possibility of using it for personal sampling of occupational dust exposure. Specific aims were to: evaluate and possibly improve the UNC sampler for stationary sampling in a working environment and compare the UNC sampler with commonly used aerosol sampling methods; characterise the impairment in performance of the UNC sampler concentrations when decreasing the number of images in order to achieve lowered costs and decreased analysis time, and; establish if the UNC sampler could be used for personal sampling in the working environment.

Methods: All sample collection in this thesis was performed in an open pit mine. For stationary sampling UNC samplers, impactors (PM$_{10}$ and PM$_{2.5}$), respirable cyclones, and an aerodynamic particle sizer were used. For personal sampling UNC samplers and respirable cyclones were used. The analysis of the UNC sampler consisted of two parts, the microscopic imaging of the deposited particles and the analysis model for calculations of mass concentration.

Results: In the first pilot study the UNC sampler with its original analysis model was used. Compared to PM$_{10}$ impactor concentrations the UNC sampler showed 58% of the impactor results and 35% of PM$_{2.5}$ impactor results. The second study showed that a new analysis model and use of higher microscopy resolution led to no underestimation compared to PM$_{2.5}$ impactors, while PM$_{10}$ improved but not to the same extent. A higher precision was also achieved compared to the respirable cyclone (intraclass correlation: 0.51 versus 0.24). When UNC sampler particle size distributions were compared to aerodynamic particle sizer data, they showed similar distributions for the new analysis model, but deviating distributions for the original analysis model. In the third study the number of images needed from the microscopic imaging process was reduced. Reducing the number of images analysed from 60 to 10 increased the coefficient of variation from 36% to 37% for respirable fraction. Finally, the UNC sampler was used for personal sampling in a working environment for the first time. Again, the particle size distribution of the new UNC sampler analysis model was reasonable, while the distribution of the original model was not. There were almost exclusively particles of mineral origin on the UNC sampler, but compared to the respirable cyclone, the UNC sampler overestimated the particle concentrations approximately 30 times.

Conclusions: The new analysis model for the UNC sampler enables stationary passive sampling of dust exposure of mineral character. Quicker microscopic image analysis, by reducing the number of images for mass concentration calculations to ten, results in a negligible loss in precision. Personal sampling with the UNC sampler showed deposited particles of reasonable size distribution and obviously originating from the working environment, but with severe overestimation of the mass concentration. Thus, the UNC sampler with the new analysis model can be used for stationary sampling in a mine, but is not yet ready for personal sampling.

Keywords
dust particles; mineral; PM$_{10}$; PM$_{2.5}$; respirable fraction; UNC passive aerosol sampler; working environment