SUBMISSION

Consultation Regulation Impact Statement:

Managing the risks of respirable crystalline silica at work

Your details

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Questionnaire

2.1 Do you agree with the identified problem? Has the entirety of the problem been identified. Please provide evidence to support your position

We do not believe that the entire problem has been identified. The simple measurement of mass of dust exposure is not necessarily indicative of the toxicity of the dust. The size, shape, surface chemistry and mineralogy of the particles will affect the health hazard. Characterisation of the dust can identify the size, shape and mineralogy of the particles. Many quartz particles are found to form micro-agglomerates as illustrated in the example of MLA characterisation (Figure 1) from an underground coal mine in Queensland. So the problem is not just as simple as the exposure to a mass of silica dust based on gravimetric or FTIR analysis. A history of the setting of the exposure standards for coal dust and silica was the subject of a previous MISHC paper, which discusses the assumptions made at the time and where these may no longer be valid [1].

The latency of dust exposure is also an important factor in silicosis. Disease can develop years after occupational exposure has ceased [2, 3]. Hnzido found that in 57% of the silicotics workers studied, the radiological signs developed on average 7.4 years after mining exposure ceased. This means the risk of silicosis was strongly dose-dependent while the latency period was largely independent of the cumulative dust exposure [4].

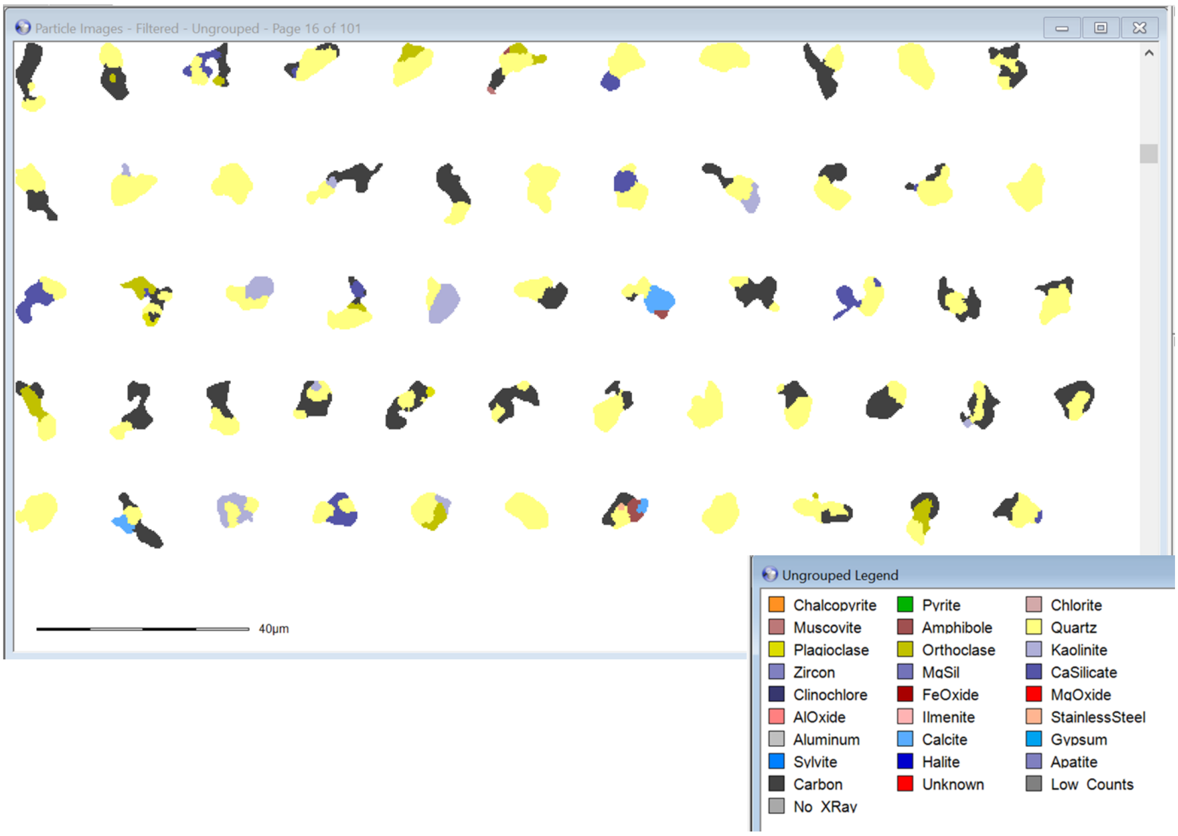


Figure 1. Example of false colour MLA images of particles containing >25% silica

MISHC has been performing characterisation work for the past 3 years including underground coal mines and underground metalliferous mines and has developed a technique for the Minerals Liberation Analyser (MLA) [5, 6]. MISHC has recently started two projects for the Office of Industrial Relations (Queensland) that include the characterisation of dust for the more underground coal mines, surface coal mine and the artificial stone industry which will provide further insight into the dust exposures in the industry.

The MISHC project in conjunction with University of Illinois Chicago (UIC) is on "Evaluating Risks for Adverse Respiratory Health in Queensland Workers Exposed to Coal Mine Dust and Respirable Crystalline Silica: Exploration and Integration of Existing Data Systems." The study will Identify occupational and individual risk factors for development and rapid progression of Mine Dust Lung Diseases include Pneumoconiosis, CWP, silicosis, asbestosis, COPD including chronic bronchitis, emphysema and dust related diffuse fibrosis.

This study covers sectors of Coal, Mineral mines and quarries, and Engineered stone industries and aims to evaluate the predictive value of early indicators on chest imaging and lung function testing. The study will analyse the existing sources of data independently and link them together including industry, job tenure, job task, chest imaging, lung function testing, dust compliance sampling. Improved understanding of the risk factors could inform regulatory efforts, guide return to work strategies, better clinical characterisation for future clinical studies examining proposed treatments.

The MISHC project in conjunction with the University of New South Wales is on “Physico-chemical characteristics and toxicity of coal mine and artificial stone particulates: Identifying factors critical to the pathogenesis and severity of coal workers’ pneumoconiosis and silicosis.”

This project seeks to both understand the pathogenesis of CWP and silicosis / advanced silicosis, as well as identify exposure scenarios that determine disease severity and the risk of disease progression. In order to address these two areas, we propose undertaking research which both better characterises the particulates and their differing components in coal mining and AS industries (both in the workplace and laboratory), and investigates the toxicity and examines pathways of disease initiation and progression in longer-term lung cell co-culture models, more representative for studying chronic diseases. Understanding the external dose and the size distribution, then its relation to dust characteristics and the level of toxicity provides the necessary progression towards understanding the pathogenesis of CWP and silicosis.

The Mineral Liberation Analyser (MLA) uses a combination of BSE (backscattered electron) image analysis and x-ray mineral identification to provide automated quantitative mineral characterization [7]. The MLA produces maps of false colour images for all minerals showing the complexity of the particles, rather than simply assigning based on the predominant mineral. The detail of the complexity of the particles is very useful given the number of particles that are micro-agglomerates of a number of minerals. Samples are collected for the MLA characterisation work with the same respirable cyclones that are used for compliance sampling along with various techniques for inhalable sample collection.

2.2 Do you have further information, analysis or data that will help measure the impact of the problem identified?

MISHC has detailed information on particles in the respirable and inhalable fractions of dust in underground coal and metals mines which have implications for all dust exposed industries.

- Particles have been found to form micro=agglomerations, which affects surface chemistry
- various mineralogies differ in particle size distributions
- Smaller particles show greater inflammation potential than larger particles

Agglomeration of particles

The characterisation work that has been going on in the US and Australia these past few years has identified that many of the airborne particulates within the mining environment form micro-agglomerations. The micro-agglomerations are complex mixtures of various mineralogies. When particles are surrounded by or coated by a different mineralogy this will be important to clearance since the function of lung macrophages can be influenced by particle surface chemistry. The mineralogies found in the micro-agglomerations as well as the dispersibility of the particles may impact the toxicity. The relative size of particles in the micro agglomeration, relative location of the various mineralogies and the relative efficiency of dispersion of the particles in the lungs all contribute to the toxicity [8].

Knowledge of the mechanism of micro-agglomeration of the particles may aid dust control technologies. If micro-agglomeration of particles can be promoted this may reduce the number of small particles in the air that can penetrate into the alveolar region of the lungs [8]. Technologies could then be targeted at the larger particles created.

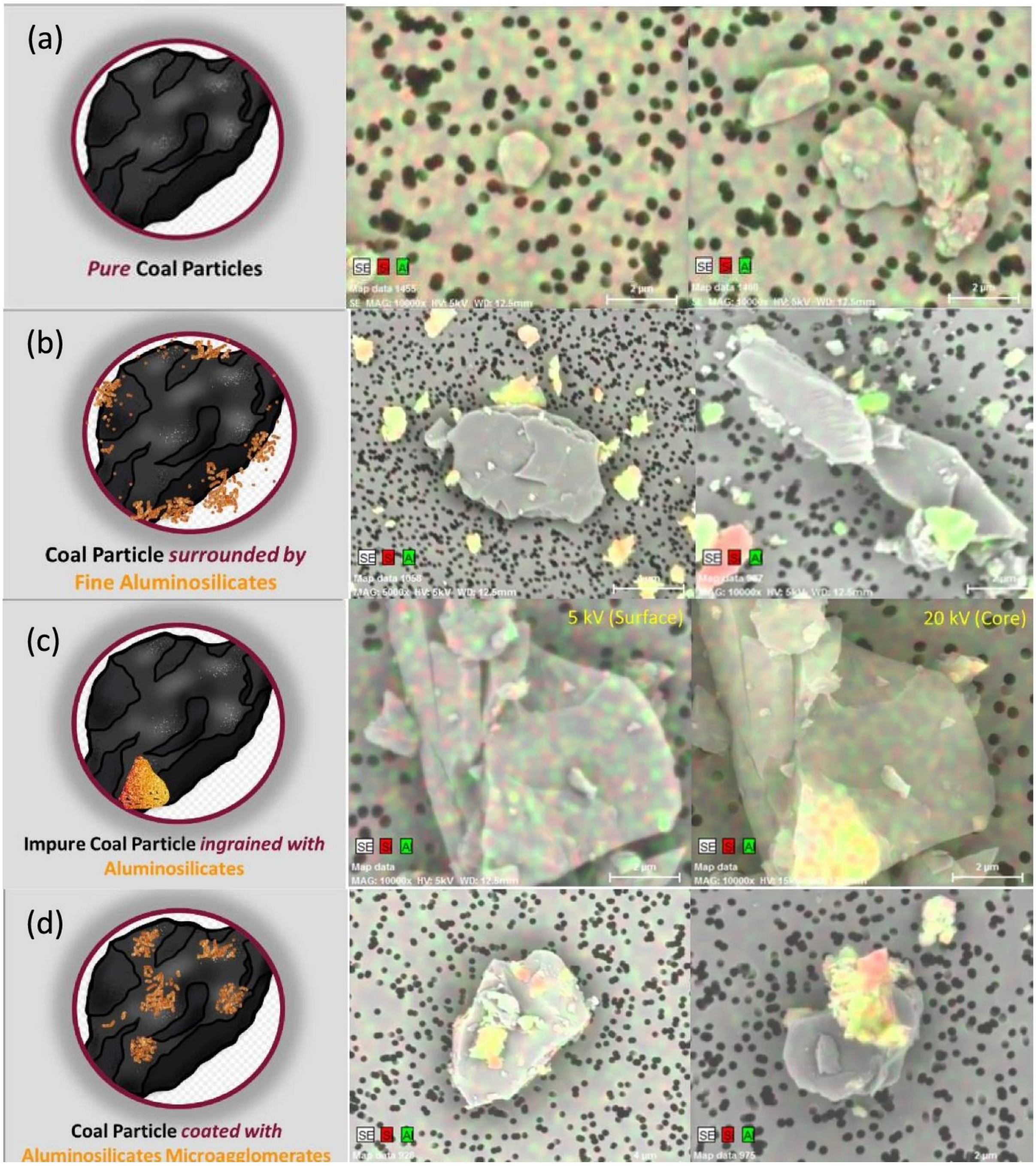
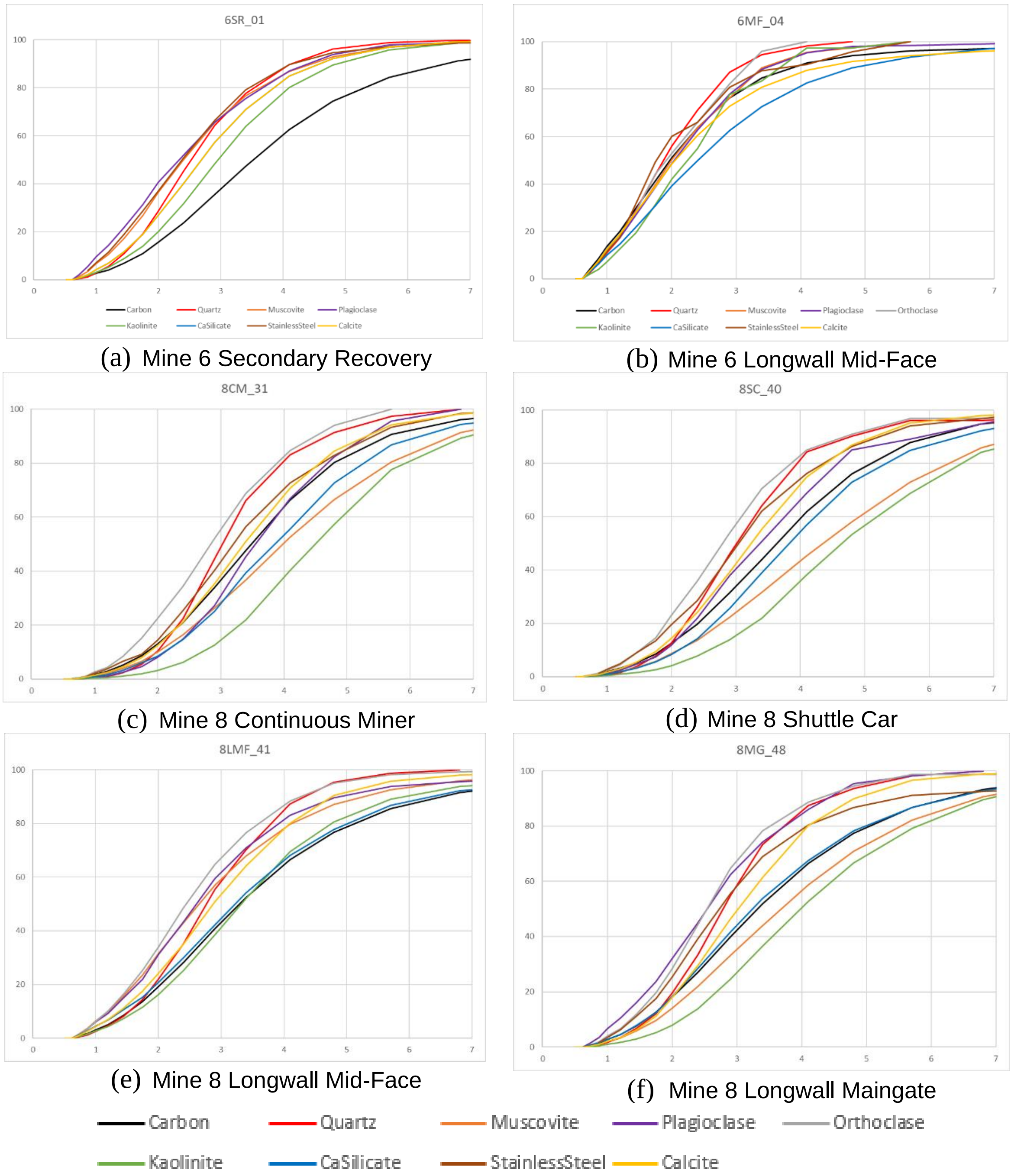


Figure 2. Types of Micro-agglomerates [8]

Particle Size Distribution

At least for coal mines, the particles containing >50% quartz have been generally found to have a finer particle size distribution (PSD) than some of the other mineralogies in the mine. The PSD of the quartz for the respirable samples is shown in red.



(a) Mine 6 Secondary Recovery

(b) Mine 6 Longwall Mid-Face

(c) Mine 8 Continuous Miner

(d) Mine 8 Shuttle Car

(e) Mine 8 Longwall Mid-Face

(f) Mine 8 Longwall Maingate

Figure 3. Particle Size Distributions of Various Mineralogical Classes by >50% weight percentage. X-axis = Equivalent Circle Diameter (microns) and Y-axis = Cumulative Passing Weight Percentage

Particle Size vs Macrophage Activation

The activation of alveolar macrophages is the first step in a complicated inflammatory cascade that leads to reactive oxygen species (ROS) and mine dust lung disease. NIOSH has completed a study looking at the differential activation of RAW 264.7 macrophages by size segregated crystalline silica. This study showed that there was a greater ROS production (a measure of inflammation) by ultrafine particles with a geometric mean of 0.3 µm than there were from the course particles with a geometric mean of 4.1 µm as seen in Figure 4 [9].

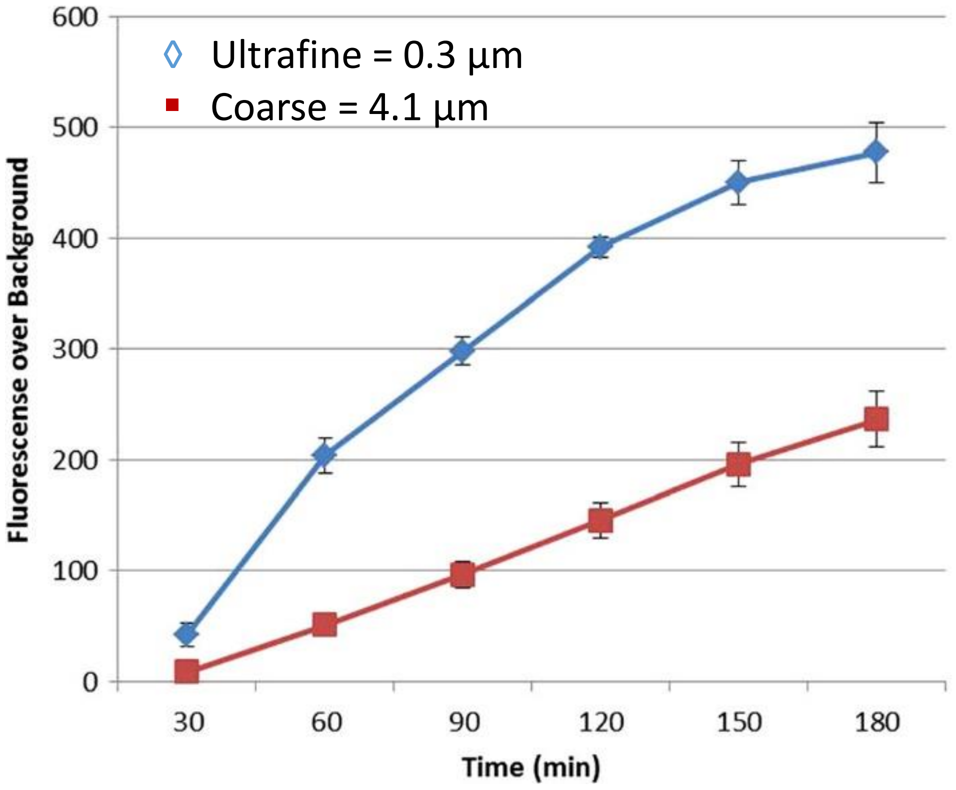


Figure 4. Macrophage activation by size segregated crystalline silica

Mass of Exposure vs Size of Particles

This issue of mass versus count of the particles presents a broader issue for particles and not be confined to silica particles. It would take 2,552 particles of a 0.3 µm diameter to equal the mass of one particle at 4.1 µm.

The current exposure standard for respirable crystalline silica is based only on the total mass of particles collected on a filter with a 0.4 µm pore size. This may not be an appropriate reflection of the actual risk to human health because the particle size distribution is not considered.

Figure 5 shows the relationship between the count of particles and the volume of particles (a proxy for mass).

Preliminary characterisation data shows consistent patterns within seam for the underground coal mines, but varies from seam to seam. Mines with a greater concentration of coarser particles would collect more mass of filter, but may not present as much of a health hazard as a mine with a greater concentration of finer particles which do not have nearly as much mass.

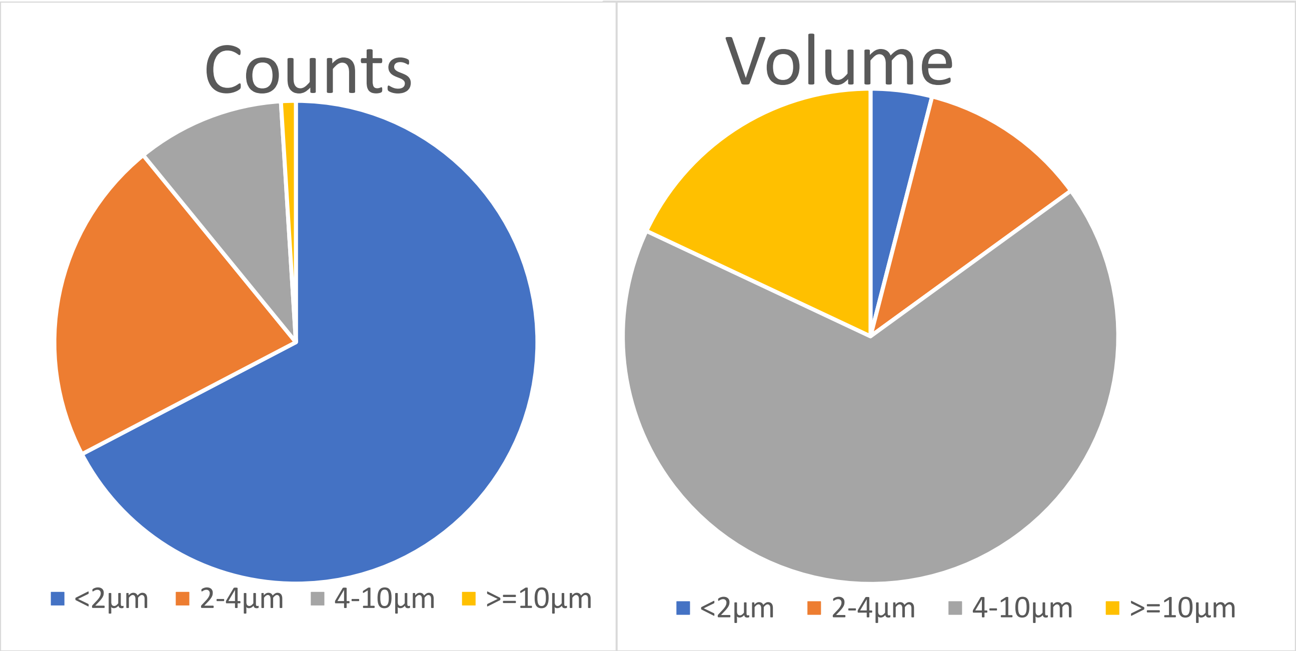


Figure 5. Count vs Volume of particles of various size fractions

Depending on the chemical composition of the particles and their size some may be more reactive than others. The number of particles and/or the surface area of those particles could play a factor.

References

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