Grant: AFC316-17
Title: Further Characterizing Respirable Coal Mine Particulates: Submicron Particles, Metals and Diesel Exhaust

Organization: Virginia Polytechnic Institute and State University

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Partnerships: University of Washington

Topic: Injury and Disease Exposure and Risk Factors
Priority Area: Surveillance and Epidemiology Methods

Problem Statement and Justification: Even with decades of efforts aimed at understanding and reducing occupational lung diseases amongst coal miners, much is still unknown about characteristics of respirable particulates in underground mines and their impacts on health. This problem is related to a variety of factors, not the least of which is that respirable dust exposures are regulated – and thus most often studied – very generally on a mass basis. In the US and elsewhere, for instance, personal exposures to respirable dust in coal mines are quantified by total mass concentration over the exposure period and mass fraction of quartz.

While measuring and targeting reductions of these quantities undoubtedly led to dramatic declines in disease incidence over several decades, in some regions (e.g., central Appalachia in the US) the downward trends in incidence rates have stalled or even appear to be reversing more recently. To date, this alarming observation is still unexplained, but key factors could certainly include lesser-known dust characteristics. For example, submicron particles or trace chemical constituents may exist in such concentrations as to negatively affect health – despite contributing relatively little to the dust mass. To shed light on worker health outcomes, a more fundamental understanding of respirable particulate characteristics is critical.

Impact of the Research: The specific aim of this project is to expand the understanding of respirable particulate characteristics in coal mining environments. In an ongoing study led by the PI, we are already determining dust characteristics that have been scarcely considered until now, namely coal to total mineral mass ratios, and size and compositional distributions of supramicron particles (i.e., 1-10μm). Here, we propose to further that work by investigating additional characteristics, which have been suggested as disease risk factors, but not explicitly studied in coal mine samples. These include: 1) size and compositional distribution of submicron particles (i.e., 0.1-1 μm); 2) mass concentration of potentially bioavailable metals (e.g., Fe, Al) and trace elements (e.g., As, Ni, Mn, Pb); and 3) mass concentration of polyaromatic hydrocarbons (PAHs). We will additionally measure 1-nitropyrene (1-NP), a PAH that is specifically associated with diesel exhaust (DE).

The primary impact of this work will be via new insights into the range of respirable particulate characteristics to which underground coal miners may be exposed. Resulting data will be valuable to both medical and epidemiological researchers studying possible causal factors for the onset and progression of lung or other diseases observed in coal miner populations; and to mining professionals seeking to reduce occupational health risks. Through these contributions, most importantly, this project will impact coal miners by leading to development of more informed best practices for dust monitoring, exposure reduction interventions, or health surveillance.

Objectives and Research Approach: As part of an ongoing project, we have collected an extensive set of respirable dust samples from underground coal mines across Appalachia. Due to use of non-destructive analytical techniques on that project, a total of 209 samples are available for further analysis. They represent multiple sampling locations (e.g., in intake and return airways, near production activities) in eight different mines. Briefly, our research objectives are to define submicron particle size and compositional distributions and measure metal, 1-NP and other PAH mass concentrations in these samples; and to determine if correlations exist between these and mine-specific variables (e.g., major particle generation activities) in locations where samples were collected. This analysis will provide quantitative data on respirable particulate characteristics that have not been measured before. It will thus help the research community bridge the gap between our heretofore only very generalized understanding of occupational exposures and miner health outcomes.