PM2.5 Airborne Particulates near Frac Sand Operations

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Abstract
The rapid growth of hydraulic fracturing for oil and gas extraction in the U.S. has led to 135 active “frac” sand mines, processing plants, and rail transfer stations in Wisconsin. Potential environmental health risks include increased truck traffic, noise, ecosystem loss, and groundwater, light, and air pollution. Emitted air contaminants include fine particulate matter (PM$_{2.5}$) and respirable crystalline silica. Inhalation of fine dust particles causes increased mortality, cardiovascular disease, lung disease, and lung cancer. In the authors’ pilot study, one of a helicopter-based ambient particulate monitor found PM$_{2.5}$ levels of 3.82–10.8 μg/m$^3$ in six 24-hour samples around frac sand mines and processing sites. Enforcement of the existing U.S. Environmental Protection Agency annual PM$_{2.5}$ standard of 12 μg/m$^3$ is likely to protect the public from silica exposure risks as well. PM$_{2.5}$ monitoring around frac sand sites is needed to ensure regulatory compliance, inform nearby communities, and protect public health.

Introduction
Hydraulic fracturing (“fracking”) is a process where a mixture of sand, water, and hydrocarbons is injected under high pressure into the ground thousands of meters vertically then horizontally to extract oil and gas. The force of injection fractures formations such as the Marcellus Shale, and the sand particles pop open fractures for subsequent oil and gas extraction. Sandstone from upper Silurian formations, including Jordan, Waukesha, Mt. Simon, and St. Peter Formations contain sand grains that are spherical, of substantial compressive strength, and aggregate size (Corey et al. 2004; Kocot, 1984–85 μm diameter) for fracking operations. frac sand mines and processing plants remove larger and smaller sand particles not used in operations) are concentrated in the upper Midwest but present throughout the U.S. and Canada (Kocot, 2014) including rail transfer sites, 135 are now active in Wisconsin (Wisconsin Center for Investigative Journalism, 2015). Wisconsin Department of Natural Resources (2017, 2012). Wisconsin Geological and Natural History Survey (2013). Rapid proliferation of these facilities—ones closely located near population centers than traditional sand and gravel operations—has led to concerns about human exposure to airborne pollutants, notably fine particulates PM$_{2.5}$ particles with a diameter of 0.1–0.5 μm and smaller) and crystalline silica (quartz). To our knowledge, this is the first publication of measured PM$_{2.5}$ concentrations around frac sand facilities.

The Wisconsin Department of Natural Resources does not regulate silica and has required less than 10% of frac sand mines and processing plants to measure the larger PM$_{10}$ fraction of airborne particulates (particles with a diameter of 10 μm and smaller). This size fraction is not as closely associated with health effects as fine particles, however, and has a much higher U.S. Environmental Protection Agency (U.S. EPA) ambient limit of 50 µg/m$^3$ compared to 12 µg/m$^3$ for PM$_{2.5}$ (U.S. EPA, 2014). Fine particulates have been identified by U.S. EPA as a cause of cardiovascular and lung disease including lung cancer. Thus comprehensive studies of silica air pollution have found that even 10 µg/m$^3$ increase in long-term average PM$_{2.5}$ concentration was associated with

- a 0 to 5% increased risk of death from all causes,
- a 6% to 26% increased risk of death from cardiovascular and lung diseases, including stroke, and
- an 8% to 37% increased risk of death from lung cancer (Lopez, Laden, Dockery, & Schwartz, 2002; Martel, 2012; O’Neill, 2012; Gries, 2013; Pope et al., 2002).

In recognition of this particular size toxicity, the U.S. EPA recently reduced the annual PM$_{2.5}$ public exposure standard from 15 to 12 µg/m$^3$.

Crystalline silica (quartz) is a particularly prominent component of the PM$_{2.5}$ size range and is occupationally associated with silicosis and lung cancer (Geller, Shaffer, Brown, Mary, & Moqbel, 2003; Park et al., 2002). "Fibrous silica" appears to be two to five times more toxic with unusual lung tissue compared to "weathered" silica, though weathering occurs over several days and with exposure to water (daily).