



Environmental Crystalline Silica Exposure in Wisconsin: A Risk Assessment and Evaluation

Gregory T. Nelson*, James Fay, Andrew Kleist – Faculty Mentor: Dr. Crispin Pierce
University of Wisconsin - Eau Claire; College of Nursing and Health Sciences; Environmental Public Health Program
*nelsongt@uwec.edu

Abstract

As many new and proposed sand mines and processing plants in Wisconsin add to the 2,300 current industrial sources, public exposure to small particles including respirable crystalline silica (RCS) is increasing rapidly. RCS occupational studies have documented causation of silicosis, tuberculosis, kidney disease and lung cancer. Exposure to the public is regulated in five states, but not in Wisconsin where the Department of Natural Resources has determined that not enough data exist to establish an exposure standard. Our approaches in Gaussian dispersion modeling, aerosol and gravimetric measurements, and citizen monitoring were used to assess PM₁₀, PM₄, PM_{2.5} and RCS levels before and after construction of a large sand processing plant to assess potential health risks in a Wisconsin community. We were unable to detect RCS upwind or downwind of the facility above the detection limit, which was twice the standard established in the State of California. We did measure increased aerosol (solid + liquid) concentrations downwind and during plant operation. We stress the need to continue monitoring with a lower detection limit in order to better determine the risks of exposure around this and other facilities.

Introduction

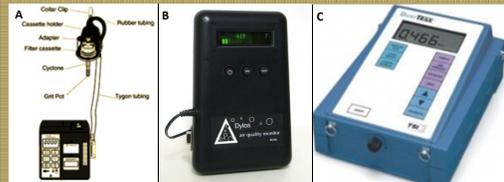
Particulate matter (PM) is a term used to describe a complex group of air pollutants that vary in size and composition. The PM mixture of fine airborne solid particles and liquid droplets (aerosols) include components of nitrates, sulfates, elemental carbon (gasoline/diesel exhaust), organic carbon compounds, acid aerosols, trace metals, and geological material like crystalline silica, for example. Crystalline silica comes in three forms: quartz, tridymite, and cristobalite, with quartz being the most common. When respirable crystalline silica, in the form of particulate matter, is inhaled into the lungs it causes scarring of the alveoli and destroys macrophages. The body's mucociliary escalator is incapable of removing crystalline silica from the lungs. This eventually leads to silicosis, a chronic lung disease, induced by the inhalation of crystalline silica. After a latent period of varying duration, lung cancer can result. Crystalline silica is classified as a human carcinogen.

Hydraulic fracturing, or "fracking," is a method of mining for natural gas common in the southeastern United States. This method of mining requires the use of special sand grains, specifically those composed of silica. Wisconsin has been found to be rich in this type of sand in the Wonewoc and Jordan formations, sandstone targeted for mining operations for the fracking industry. Mining/processing operations such as the EOG facility in Chippewa Falls releases airborne sand particles, possibly posing a risk to public health. Currently, five states have environmental exposure standards for silica. The Wisconsin DNR admits that silica is a carcinogen but is currently not regulating it.

Here, we assess this risk through sampling for airborne crystalline silica as well as counting the number of particles in the air up- and down-wind before and after the site is in operation. Then we use our data to evaluate the potential risk to public health by comparing empirical results to established safety standards and provide recommendations with the goal of safeguarding public health.

Methods

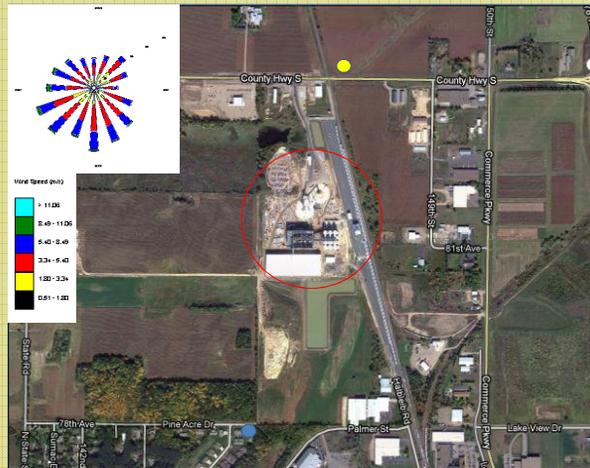
- Study was conducted at the EOG Sand Processing Facility in Chippewa Falls, Wisconsin
- Measurements were taken up and down wind before the facility was in operation as well as after the beginning of operations
- Three types of measurements were conducted: respirable (PM₄) crystalline silica (RCS), small (0.1-2.5 μm) and large (< 2.5 μm) aerosol count, and PM₄ aerosol mass.
- RCS was measured using a personal sampling train provided by the Wisconsin Occupational Health Laboratory (A).
- Total small and large particulates were measured using a Dyllos laser aerosol counter (B)
- Grab samples of mass/volume content was measured using a DustTrak mass counter (C)



Silica sampling equipment. A pump draws air through a filter, which catches particle-matter. The filter was sent to WOHHL for gravimetric and x-ray diffraction analysis.

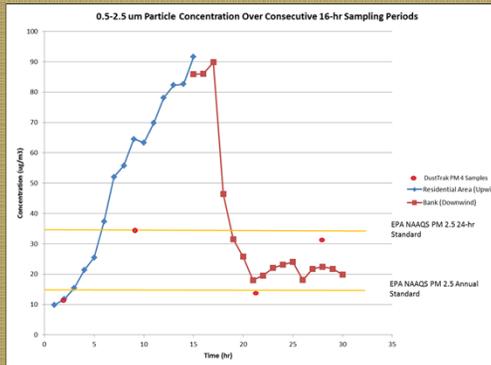
Aerosol counter. A fan is used to draw air through a laser that counts suspended solids and liquids as they pass. Distinguishes between small (0.1-2.5 μm) and large (< 2.5 μm) aerosols.

DustTrak mass counter. A pump is used to draw air through a cyclone that allows aerosols 4 μm and smaller to be measured by 90° light scattering to give a readout in mg/m³.



The EOG sand processing plant (circled in red) in Chippewa Falls, WI with regional average summer wind rose depicting the direction the wind is blowing from. Sample sites are indicated with filled circles; upwind (blue - residential) and downwind (orange - bank, yellow-filled).

Results

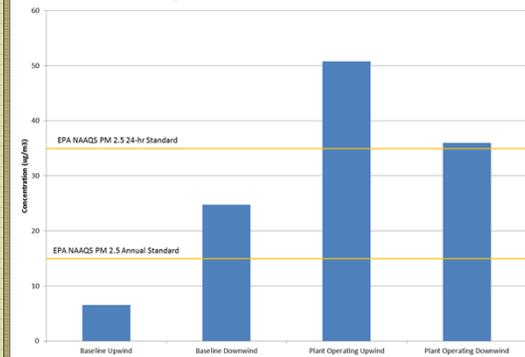


Real time Dyllos particle counts for small (0.1-2.5 μm) particles at the upwind and downwind locations. Measurements were taken in November of 2011, after the facility was open for operations. Yellow lines indicate EPA daily and annual standards for PM_{2.5}. Although the EPA threshold was exceeded, the Dyllos monitor is known to count water particles (mist) and particle counts often spiked during moist evenings. DustTrak data agreed with Dyllos results and seemed to be less sensitive to air water content.

LAB NUMBER	FIELD NUMBER	DESCRIPTION	CONCENTRATION	CONCENTRATION	AIR VOLUME
1507040	2PJT	Respirable Dust	< 0.03 ug/m ³	< 0.03 ug/m ³	160 l/min
1507041	2PJT	Respirable Dust	< 0.03 ug/m ³	< 0.03 ug/m ³	157 l/min
1507042	2PJT	Respirable Dust	< 0.03 ug/m ³	< 0.03 ug/m ³	162 l/min
1507043	2PJT	Respirable Dust	< 0.03 ug/m ³	< 0.03 ug/m ³	150 l/min
1507044	2PJT	Respirable Dust	< 0.03 ug/m ³	< 0.03 ug/m ³	157 l/min

Analytical x-ray diffraction results for downwind respirable particulate and crystalline silica samples taken at the EOG site during operations (November 2011) from the Wisconsin Occupational Health Laboratory (WOHL). Both dust and silica were below our detection limits. Our detection limit for dust was 33 μg/m³ per sample. Our detection limit for silica was 6.2 μg/m³. These values are twice the established standards.

Average 0.5-2.5 μm Particulate Concentrations



Averaged aerosol counts for both baseline (July 2011) and while in operation (November 2011) compared to EPA standards. Aerosol levels increased after operations began.

Discussion

- Total aerosol concentration increased after the site began its operations; this indicates that the site is responsible for the degradation of air quality in the area to some degree
- Laser and 90° light scattering aerosol counters were sensitive to air moisture content making it difficult to determine the risk of air particle content with these measurements
- Respirable particle concentrations were below our detection limit; because our detection limit was twice exposure standards we cannot determine the risk of exposure accurately
- Respirable silica content was found to be below our detection limit; because our detection limit was twice the exposure standard we cannot determine the risk of exposure accurately
- Our measurements were one time samples and aerosol/silica content but the generation of these particles is continuous and varies with time
- We sampled one location but different sand facilities have different processes and procedures making exposure levels case specific per site
- Because we were unable to determine the exact amount of particles/silica we are unable to determine the risk of exposure. Our limits were twice the exposure standards, meaning they could be at dangerous levels but we would not be able to tell. We recommend longer term risk identification with lower detection limits in order to better determine exposure levels at this facility. Because each site is unique it is also recommended that these measures be taken at other facilities.

References

- International Agency for Research on Cancer (IARC) (1997). Silica, some silicates, coal dust and para-aramid fibrils. Lyon, France, International Agency for Research on Cancer, pp. 1-242, IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol. 68.
- NIOSH (2002). Health Effects of Occupational Exposure to Respirable Crystalline Silica: NIOSH Hazard Review. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.
- "PM Standards | Particulate Matter | Air & Radiation | US EPA." *US Environmental Protection Agency*. 16 Mar. 2011. Web. 17 Apr. 2011. <http://www.epa.gov/pm/standards.html>.
- United States. Wisconsin Department of Natural Resources. *Status Report to the Natural Resources Board*. Dec. 2010. Web. 1 Apr. 2011. <http://dnr.wi.gov/air/pdf/DraftForPublicComment-SilicaStudyStatusReport.pdf>.

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