Sand Mining and Transport: Potential Health Effects

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Hydraulic Fracturing Well

http://www.sustainable.co.za/blog/2013/10/karoo-fracking-what-you-need-to-know/
Sand In The Heartland

- 500-million-year-old rock formations contain high quality silica sand
- Deposits particularly well-suited for hydraulic fracturing (fracking)
  - Round and hard
  - Can be screened to be a certain size
- Ideal for use as a proppant to hold open fissures in stone in a frack well

Example In Illinois

Peru/Lasalle

Ottawa

Starved Rock State Park
Sand Mining

Remove overburden

Extract deposit

Transport to processing


Sand Processing & Shipping


Barge

Truck

Train
http://www.hulcher.com/industries/frac-sand/
Many Complex Issues

• Community issues involved in deciding whether to develop this resource

**Pros**
- Develop economic base
- Increase jobs

**Cons**
- Increase pollution
- Increase noise, trucking
- Road wear
- Loss of natural beauty
- Loss of tourism

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Particulate Matter (PM) Air Pollution

- **Hot processes**
  - Vapor → particle
  - $D_p < 1 \, \mu m$
  - Combustion (e.g., diesel engine)

- **Mechanical processes**
  - $D_p > 1 \, \mu m$
  - Grinding, sanding, excavating

[Diagram of particle generation]

Basis for PM Regulation

- Increased respiratory symptoms, such as irritation of the airways, coughing, or difficulty breathing
- Decreased lung function
- Aggravated asthma
- Development of chronic bronchitis
- Premature death in people with heart or lung disease
PM Regulations

• EPA (community health)
  – All particle types
  – PM smaller than 10 um (PM$_{10}$)
    ❖ <155 ug/m$^3$ over 24-hr
  – PM smaller than 2.5 um (PM$_{2.5}$)
    ❖ <12 ug/m$^3$ annual avg; <35 ug/m$^3$ over 24-hr
  – Only measured in 8 locations in Iowa
  – State issues permits to ensure compliance

• MSHA and OSHA (worker health)
  – Respirable (~PM$_{4}$)
    ❖ Particles that enter the deep lung
    ❖ All particle types and specific compounds
Respirable Crystalline Silica

• Specific component of PM of concern for mining of sand
  – Silicosis (fibrosis or scarring of lung)
  – Lung cancer

• Regulatory levels
  – OSHA
    ❖ PM$_4$ - 100 µg/m$^3$
    ❖ Protect workers
  – Some states (MN, CA)
    ❖ PM$_4$ - 3 µg/m$^3$
    ❖ Protect everyone, including venerable populations
Silicosis

- Repeat injury; granuloma formation; scarring
- Gradual progression
- Once scarring, generally irreversible
Are there risks?

We know PM and respirable crystalline silica are hazards. But what about from sand activities?

What do we know about exposures?

Exposures From Sand Mining, Processing, and Handling

• Sand mining and processing generate airborne PM and respirable crystalline silica
  – Blast, load, and haul
  – Process activities such as crushing
  – Shipping and disposal of “waste sand”

• Occupational exposures (miners, transporters)
  – Common to exceed OSHA standards for respirable crystalline silica
  – Ways to control are well documented

• Community exposures
  – Less clear
  – No required monitoring
Our Work:
Answer Several Questions

1. Is particulate matter from sand mining operations hazardous?

2. What are community exposures to PM and respirable crystalline silica?

3. What are risks of developing adverse health effects from inhalation of particulate matter from a sand mine?
Is PM from sand mining operations hazardous?

- Collected sand types
  - Unprocessed sand from mine
  - Processed frac sand

- Characterize physicochemical properties
  - Size distribution
  - Composition

- Evaluating toxicity
  - Cell testing (\textit{in vitro})

Done

On-going

Summer
Sieve Analysis

- **Mine Sand**
  - Largest sand removed
  - Some ‘fines’ removed but a lot still present
  - ‘Fines’ present - health hazard

- **Processed Sand**
  - ‘Fines’

 Particle Diameter, µm

- Large sand removed
- Some ‘fines’ removed but a lot still present
- ‘Fines’ present - health hazard
Wind blowing over mine sand or processed sand can generate airborne respirable particles.

Next, we will assess crystalline silica content.
What are community exposures to PM and respirable crystalline silica?

- Atmospheric dispersion modeling
- Air monitoring and sampling
Sites to Model

- Processing Plant with Sand Piles
- Sand Mine
Model Inputs And Receptors

Model Inputs

- Dust emission rates for sources
- Topography
- Meteorological data

Wind Rose
Sand Processing
Emission Sources

Sand from mine

Wash & Screen

Dry to remove moisture

Silo Storage

Load on trains
PM10 Without Fugitive Emissions

Highest values

Preschool

Hospital

PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL
Max: 1533 [µg/m³] at (628099.00, 4979982.00)
Open Mine Modeling

• WDNR Lists the following as sources of PM
  – Drilling
  – Blasting
  – Crushing
  – Screening
  – Conveyers/Stackers
  – Material Handling
  – Paved Hauling
Air Sampling And Monitoring

• Traditional air sampling
  – EPA reference method sampling in towns with heavy mining
  – Respirable crystalline silica monitoring outside homes

• Real-time monitoring
  – First deployment trains carrying sand
  – Other processes (load barges, processing plants, etc)

• Low-cost detectors
  – <~$1k for continuous monitoring of mine or process
Real-time Monitoring

Camera

Sound and Vibration Triggers

Particle Monitor

60-80 trains per day pass on two tracks
Trains Cause Spike In PM$_{10}$

Almost all spikes in concentration correlate with train passing.

Sometimes spike missing or much lower.

Next: Associate types of trains from pictures with spikes.

Clear problem with train detection; suspect wind.
Low-Cost Detectors

- Best practices to suppress dust from sand mining operations are available

- However, no monitoring is performed to ensure practices are followed
  - EPA monitors are too expensive ($20K each)

- We will apply low-cost detectors ($400) to assess PM concentrations near sand mines
Summary

• Sand is big business in the Heartland of the US

• Sand mining operations present complicated issues that state agencies and local communities must deal with

• We hope to answer some key questions related to ambient air exposures
  – PM$_4$ / respirable crystalline silica
  – PM$_{2.5}$ / PM$_{10}$