Hello, this is Kevin O'Donovan, and I'd like to welcome you to the National Institute of Environmental Health Sciences Superfund Research Program monthly Research Brief podcast.

This month, we discuss Dr. Betterton's investigation of particle size and chemical characterization of dust from mining sites in Arizona.

The Research Brief, Number 202, was released on October 5, 2011, and was written by SRP contractor Maureen Avakian in conjunction with SRP-supported researcher Dr. Eric Betterton.

Crushing, grinding, smelting, refining, and tailings management operations at mines are important sources of airborne particulates that can contain metalloids such as arsenic and lead. Human exposures to this dust can occur through inhalation and ingestion. Children are more likely than adults to ingest dust and are more vulnerable to the effects of toxic contaminants.

Characterization of airborne dust in regions influenced by mining activity can provide information about sources, fate and transport, and the potential for human exposures.

Particle size affects residence times (how long a particle stays suspended in the atmosphere); smaller particles stay airborne longer. This influences fate and transport, leading to clues about contaminant sources. Coarse particles (>2.5 µm) are generally created through mechanical action, such as crushing, grinding, or by strong winds, and have residence times of a few hours. By contrast, the fine particles (<2.5 µm) that result from smelting and refining operations have residence times as long as 10 days and can disperse more widely into the environment.

Particle diameter affects aerosol deposition in the human respiratory system. Coarse particles are mainly deposited in the upper respiratory tract (nasal cavity, pharynx, and larynx). They are ultimately swallowed and eliminated through the digestive system. In contrast, fine particles penetrate more deeply into the lungs and can be transferred directly to the blood stream. Thus, determining the distribution of toxic metals in dust fractions also has important implications for human exposure and public health.

At the University of Arizona's Superfund Research Program (UA SRP), scientists led by Dr. Eric A. Betterton and Dr. A. Eduardo Sáez are performing size-resolved chemical characterization of atmospheric aerosols near mining sites in Arizona. By determining the chemical components of mine tailings dust as a function of particle diameter, their research will generate source apportionment data, improve fate and transport models of airborne particulates, and better assess potential health impacts of contaminated dust.

Dr. Betterton and Dr. Sáez's group performed size-resolved chemical characterization of atmospheric aerosols sampled over a period of a year near an active copper mine and smelter site in Hayden, Arizona. In addition to standard measurements using a total suspended particulate (TSP) collector, aerosols were characterized with a 10-stage (0.054 to 18 µm aerodynamic diameter) multiple orifice uniform deposit impactor (MOUDI) and a scanning mobility particle sizer (SMPS).

The MOUDI yields mass concentration of particulates by particle diameter, while the SMPS yields number and volume concentration by particle diameter. The collected particulates were analyzed for metal content by inductively-coupled plasma mass spectroscopy.

TSP samples collected at the active mining and smelting site in Hayden were compared to other sites in southeast Arizona: a clean mountain-top site, a metal-free mine tailings site, and a typical urban environment. These comparisons demonstrated that airborne arsenic and lead were at least 9 and 4 times higher, respectively, at the Hayden site than any of the other sites sampled.

Scanning electron microscopy and electron dispersive spectroscopy revealed the presence of globular arsenic- and lead-containing particulates, suggesting a history of high-temperature processing in fine-fraction samples collected in Hayden.

The MOUDI samples that showed both arsenic and lead concentrations followed a bimodal distribution, with maxima centered at approximately 0.32 µm and 7.0 µm particle diameter. The irregular fractured nature of particles containing arsenic and lead in the coarse-size fraction (>2.5 µm) suggest that they originate as windblown dust from mine tailings and other sources. The globular fine fraction (<2.5 µm) contained approximately 70% of the total arsenic and lead, which is likely the product of condensation and coagulation of smelting vapors. In support of this, SMPS data showed the highest readings of ultrafine particle number concentration when the wind came from the general direction of the smelter. Unfortunately, particles detected by the SMPS cannot be chemically analyzed and therefore cannot be assigned to a source. Thus, the ultrafine particles observed with the SMPS could be associated with arsenic or lead vapor, or sulfuric acid production at the smelter.

More detailed observations of dust fluxes at a Superfund site in Dewey-Humboldt, AZ, will be used to develop a model for the horizontal and vertical flux of particles, and to further characterize contaminant transport from mining and smelting operations. Additionally, Drs. Betterton and Sáez are working with other UA SRP investigators: first, to see if vegetation cover at this site will reduce dust; and second, to supply actual size-fractionated dust samples for analysis of arsenic solid-phase speciation and for inhaled arsenic toxicity studies. Together, these UA SRP projects will provide insights into the source, fate and transport, and health effects of metal-contaminated airborne particulates.

To our knowledge, this is the first demonstration of size-resolved atmospheric aerosols associated with arsenic and lead in the vicinity of mining operations, information necessary for source apportionment and exposure assessment. The location of many mining operations in dry climates, in addition to the warmer, drier conditions predicted for the Southwestern US, may make contaminated atmospheric dust and aerosols an increasingly important exposure route that could result in adverse effects on human health and ecology.

If you'd like to learn more about this research, visit the Superfund Research Program website at www.niehs.nih.gov/srp. From there, click on "Who We Fund" and follow the links to the University of Arizona research summary. If you have any questions or comments about this month's podcast or if you have ideas for future podcasts, contact Maureen Avakian at avakian@niehs.nih.gov.

Join us next month as we discuss Dr. Van Geen's research on arsenic migration to deep groundwater in Bangladesh.