

*The purpose of this briefing is to provide a general overview about the occurrences of arsenic and its environmental and health impacts. SME through this discussion presents information to inform and engage in meaningful dialogue about safety and best practices utilized by the mining industry in extracting sulfur-based minerals that may include arsenic. Technical references regarding the health and environmental impacts of arsenic are noted at the end of this briefing.*

## Issue

Arsenic is a naturally occurring element commonly found as an impurity in metal ores, and is produced commercially for use in pesticides, wood preservatives, and metal alloys. Arsenic can be toxic in large doses, and the mining industry monitors and prevents its release into the environment. [32]

## Background

Arsenic is the 20th most abundant component of the Earth's crust, and is widely distributed in rocks and soil, in natural waters, and in small amounts in most living things. [1] It is a metalloid, which means that it can behave as a metal or as a nonmetal. [2] Arsenic is rarely found as a pure metal, but is often a component in sulfur-containing minerals, the most common of which is arsenopyrite. [2] Commercially, arsenic is produced as arsenic trioxide or as a pure metal. [3] However, these have not been produced in the United States since 1985. Limited quantities of arsenic metal have been recovered from gallium-arsenide semiconductor scrap. [23] Arsenic may also be obtained from copper, gold, and lead smelter flue dust as well as from roasting arsenopyrite, the most abundant ore mineral of arsenic. However, arsenic is not recovered from these sources but is rather disposed of in an environmentally safe manner. Arsenic has been commercially recovered from realgar and orpiment in China, Peru, and the Philippines, and from copper-gold ores in Chile. Arsenic also may be recovered from enargite, a copper mineral. Global resources of copper and lead bearing minerals contain approximately 11 million tons of arsenic. [23]

## Arsenic toxicity

Inorganic arsenic is classified as a known human carcinogen by the International Agency for Research on Cancer. [32] Consuming a large amount of arsenic over a lifetime can increase the risk of cancer in internal organs such as the bladder, lungs, and liver. [4] In areas with naturally high levels of arsenic in the groundwater, arsenic poisoning from drinking water is a serious concern. [5] Countries with elevated arsenic levels in their groundwater include Bangladesh, Taiwan, Mexico, Chile, China, and India. [5] High concentrations of arsenic in lakes and streams can also be lethal to freshwater fish, invertebrates, and plant life. [6]

## Natural sources of arsenic

Arsenic is released into the environment naturally through the weathering, oxidation and erosion of sulfide minerals. [1] These sulfide minerals can form soils with very high concentrations of arsenic, and the arsenic can dissolve in water. [1] An estimated 25% of arsenic emissions into the atmosphere come from natural sources, mostly volcanoes. [8] The majority of the arsenic released by all sources end up in the soil and the ocean. [8]

Since valuable metals such as copper and gold can also be found in sulfide mineral deposits, mining exploration companies will often look for soil and water with a naturally high arsenic content as a means of locating an ore body. [9] It is, therefore, very important to establish baseline or existing arsenic concentrations in the surrounding environment in order to distinguish between mining, mineral processing, and the metallurgical industries; other human contamination (pesticides, fungicides); and natural background levels. [10] The

measurement of baseline concentrations is usually part of environmental impact assessment processes practiced in more than 100 countries. [11]

### **Human activities which intensify the release of arsenic**

A number of human activities have the potential to increase arsenic concentrations in the air, water, and soil on a local scale. [1] The rate of arsenic release from sulfide minerals can be accelerated by mining activities, which expose the minerals to weathering processes during excavation. [1] Arsenic oxide dust is produced during copper and gold smelting, and coal combustion. [8] The direct application of arsenic in the form of pesticides, fungicides or wood preservatives has historically been a major source of arsenic in soils, as arsenic is strongly attracted to soil particles and sediments. [1] Freshwaters and associated ecosystems may be impacted by arsenic dissolution in runoff from contaminated sites. [1] In contrast, it is the natural release of arsenic from geologic materials which has become a threat to drinking water supplies around the world. [5]

### **Arsenic in the mining industry**

Atmospheric arsenic emissions from copper smelting represent the largest contribution of arsenic from the mining and metals industry by far and have been the focus of pollution control technologies and increasingly stringent regulations. [8] Arsenic can also be leached out of some metal ores by cyanide or acid rock drainage but can be captured and removed from wastewater before it is released into the environment. [12]

Arsenic is also present in coal used to generate electricity. When coal is burned, ash is produced which contains most of the naturally occurring arsenic. More than 99% of the ash is collected and is either sent to specially-designed ash ponds or disposal sites or recycled into commercial products. [31]

Like other industries, mining is strictly regulated and monitored by multiple government departments, agencies, and bureaus at the local, state and federal levels. Regulations, including EPA's Resource Conservation and Recovery Act and Land Disposal Restrictions, have both narrative and numerical criteria and standards for protection of human health, aquatic life, air quality, endangered and threatened species, disposal of solid wastes and the environment, in general.

### **How the mining industry prevents arsenic pollution**

A number of technologies are being used to capture and remove arsenic from smelting stacks and mine tailings. Air pollution can be controlled effectively using scrubbers, electrostatic precipitators, and baghouses in smelters, which are capable of removing up to 99.7% of the dust and fumes produced during roasting and smelting. [13] Mine tailings and wastewater can be treated for arsenic removal using present day technologies, e.g. the use of ferric reagents to precipitate and absorb dissolved arsenic species into disposable iron compounds. [14] Aqueous arsenic species can also be filtered from waste and tailings with a variety of adsorbents, including iron oxides, clay liners, and activated charcoal filters, which can be disposed of safely. [14] The use of plants, wetlands, and iron nanoparticles to remove arsenic from already contaminated areas is also presently being investigated. [14, 15]

The appropriate state of the art and advanced technologies and protocols for monitoring, analyzing, treating and disposing of all types of liquid and solid wastes containing arsenic are available and applied in the mining industry when and where required to ensure the appropriate level of protection for humans and the environment.

### **Uses of arsenic**

The reported world production of arsenic was 46,000 tons in 2014. [23] Demand for arsenic has been declining since the 1970s when inorganic arsenic salts were still used extensively as pesticides. [8] Globally, an estimated 50% of arsenic produced continues to be used to make arsenic-based insecticides and herbicides, and another 30% is used to make chromated copper arsenate (CCA) wood preservatives widely used in marine applications

and timber poles. Canada and the U.S. entered into a voluntary agreement in 2003 to ban the use of CCA in residential applications. [1, 24] The electronics industry uses 5% of the arsenic produced to make gallium-arsenic semiconductors for use in cell phones, solar panels, and light emitting diodes (LEDs), and the remaining 15% is used in glassmaking, and to harden metal alloys in ammunition, solders, and bearings. [24]

### **Arsenic production**

Arsenic trioxide is obtained as a byproduct from dusts and residues produced during the treatment of other metal ores such as gold and copper. [25] The arsenic trioxide can be purified on site or sold to a refinery. [7] China is the world's leading producer of arsenic (25,000 tons in 2014) followed by Chile (10,000 tons) and Morocco (8,000 tons). [23]

### **SME Statement of Technical Position**

- Arsenic is a naturally occurring element commonly found as an impurity in metal bearing mineral ores.
- Arsenic is widely distributed in rocks and soil, in natural waters, and in small amounts in most living things.
- The direct application of arsenic in the form of pesticides, fungicides or wood preservatives has historically been a major source of arsenic in soils, as arsenic is strongly attracted to soil particles and sediments.
- The natural release of arsenic from geologic materials which has become a threat to drinking water supplies around the world.
- The rate of arsenic release from sulfide minerals can be accelerated by mining activities, which expose the minerals to weathering processes during excavation. Also, arsenic can be mobilized by weathering of outdoor stored waste byproducts produced during the subsequent metal value recovery process.
- It is, therefore, very important to establish a baseline of arsenic concentrations in the surrounding environment in order to distinguish between mining, mineral and metallurgical processing; human activities; and natural background levels.
- The mining, mineral processing and metallurgical industries support, and strictly follow, state and federal regulations to ensure protection of the environment and the health of industry workers.

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