ARSENIC

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In 2002, the United States produced no arsenic and remained dependent on imported arsenic trioxide and arsenic metal for domestic needs. As in past years, China was the principal supplier of arsenic trioxide and arsenic metal for the United States. Japan was an important source of arsenic metal, and Chile and Morocco were secondary sources of arsenic trioxide. There has been no domestic production of arsenic since 1985.

Legislation and Government Programs

For more than 50 years, chromated copper arsenate (CCA), which may contain up to 22% arsenic (Richmond-Times Dispatch, 2001), has been the main preservative used for wood products that are used out-of-doors. U.S. manufacturers of arsenical wood preservatives have begun a voluntary transition from CCA to alternative wood preservatives after consultations with the U.S. Environmental Protection Agency (EPA) and in response to consumer concerns (American Wood Preservers Institute, 2003§[1]; Osmose, 2002§). Major U.S. producers of arsenical wood preservatives include Arch Wood Protection Inc., GA; Chemical Specialties Inc., NC; and Osmose Wood Preserving Inc., NY. Alternatives to CCA-treated products include copper azole, copper citrate, and alkaline copper quaternary (Health Canada, 2003§). Other preservative agents include ammoniacal copper zinc arsenate and ammoniacal copper quaternary (Commonwealth of Pennsylvania Department of Environmental Protection, 1999§). Wood-polymer lumber made from reclaimed plastic and wood waste may be substituted for CCA-treated wood (Trex, 2003§). The phasing out of CCA-treated wood for certain residential uses, such as play structures, picnic tables, decks, fencing, and boardwalks, is scheduled to be completed by December 31, 2003. Wood treated prior to that date may still be used, and structures already in place will not be affected. Industrial-use wood products, such as marine timber and pilings, utility poles, shakes and shingles, plywood roof decking, plywood flooring, and glue-laminated beams, however, will still be treated with CCA. The EPA has indicated that there is no reason to remove CCA-treated structures, nor does the EPA recommend removing soils that are near these structures. In order to better inform buyers, however, the EPA requires that CCA-treated lumber be labeled to indicate that the product contains arsenic (St. Petersburg Times, 2001§). For example, a residential deck may contain more than 1.5 pounds of arsenic, and degradation or disposal of this wood, whether in a landfill or incinerator, is of environmental concern (Bleiwas, 2003§).

Under the authority of the Safe Drinking Water Act, the EPA has required that the arsenic content of drinking water be reduced to a more stringent standard of 10 parts per billion (ppb) from a standard of 50 ppb. The EPA adopted the new standard in January 2001, and public water systems in the United States will have until January 2006 to comply (U.S. Environmental Protection Agency, 2001§).

The U.S. Geological Survey (USGS) has found that arsenic levels in Lake Anne, near the USGS headquarters in Reston, VA, "exceeded what would be expected to occur naturally in this setting." It is likely that CCA-treated wood used for decks and fences in the residential area around the lake contributed one-half of the arsenic in the lake sediments, with the remainder coming from other sources of CCA-treated wood upstream (Rice and others, 2002; Reston Connection, 2003).

Arsenic is one of several pollutants generated by coal-fired power stations, and pollution from these stations has been blamed for some respiratory problems (Planin, 2001). Collaborative studies by the EPA and the USGS indicated that, with the possible exception of mercury, there is no evidence to indicate that emissions from U.S. coal-burning plants cause human health problems (Finkelman, 2000). U.S coal contains an average of 22 parts per million arsenic, and combustion of these coals is not considered a health risk; however, there are high-arsenic coals in China that pose a health risk when the arsenic is released during combustion of coal for domestic use. The USGS, in partnership with Chinese health officials, is working to address health issues related to the release of arsenic and other elements as a result of domestic coal use in rural China (U.S. Geological Survey, 1998§).

During April 2003, the USGS cosponsored a Natural Science and Public Health Conference in Reston, VA. Research topics that were discussed included arsenic in ground water in Michigan, estimates of U.S. ground water arsenic concentrations, drinking water arsenic levels, and arsenic in metal-rich coals in China. USGS arsenic-related research programs encompass arsenic associated with massive sulfide deposits in the Eastern United States (Robert Seal, U.S. Geological Survey, oral commun., May 2003); arsenic in ground water (Welch and others, 2000§); the impact of regional geology on ground water in New England (Ayotte, 2000§); arsenic contamination associated with abandoned mines in California (Alpers, 2002§); elevated arsenic content of water wells in Iowa (Iowa Times Citizen, 2003§); transport of arsenic from poultry feed amendments into the Chesapeake Bay Watershed (Hancock and others, 2003§); arsenic contamination of wells caused by pesticides (Ayuso and Foley, 2002§); bedrock mineralogical pathways of arsenic in New England (Robinson and others, 2002§); arsenic and other trace elements in the Cheney Reservoir watershed, KS (Mau, 2001); and water quality in the lower Illinois River Basin, IL (Groschen and others, 2001).

Arsenic contamination of soils may be longlived. For example, the USGS has contributed to studies of arsenic leached into ground water from Civil War period cemeteries in Iowa

[1]References that include a section mark (§) are found in the Internet References Cited section.

when arsenic was used as an embalming fluid (Konefes and McGee, 1999§). At the site of a 1940s chemical weapons testing station in a residential area of Washington, DC, the arsenic content of soils was determined to be above the risk benchmark set by the EPA (Bohlen, 2003).

Consumption

In 2002, the United States remained the world's leading consumer of arsenic, with an estimated demand of 19,600 metric tons. This demand was the lowest in more than a decade. The estimated value of arsenic consumed domestically during 2002 was approximately $18 million. Arsenic was consumed mainly as arsenic trioxide, and as in previous years, the chief end use of arsenic trioxide was in the production of CCA wood preservatives. Approximately 90% of the arsenic, as arsenic trioxide, was used in the wood preservative industry; the balance was used in agricultural chemicals, such as insecticides, herbicides, and fertilizers. Uses of other arsenic compounds and arsenic metal include electronics, pigments, metal alloys, and as a bubble dispersant or decoloring agent in glassmaking.

The demand for arsenic metal is limited; however, arsenic metal may be alloyed with lead and antimony for ammunition, solders, and other applications. Arsenic is one of several metals used as an antifriction additive to metals (babbitts) used for bearings (Allen, 2000§). Grids and posts in lead-acid storage batteries are strengthened by the addition of arsenic metal. Gallium-arsenic and indium-arsenic semiconductors for use in computers and electronic devices require high-purity (99.9999%-pure) arsenic metal. Consumption of arsenic metal for electronics applications has declined since 2000-2001 in response to a decrease in demand for electronic products.

World Review

In 2002, arsenic trioxide was obtained from the treatment of nonferrous ores or concentrates in 14 countries. Smelter dusts and residues were recovered from plants in several other countries; however, these were not processed to commercial-grade arsenic trioxide and may be stockpiled for future treatment. In 2002, China was still the world's largest producer of arsenic trioxide, followed by Chile. Most countries do not report their arsenic trioxide production, and therefore, most country data are estimated.

Reduction of arsenic trioxide accounts for all world output of commercial-grade (99%-pure) arsenic metal. China continues to be the world's leader in production of commercial-grade arsenic metal, followed by Japan.

Outlook

World resources of arsenic are adequate to meet projected needs given the availability of arsenic from nonferrous metal processing in several countries.

The decision by the wood preservative industry to voluntarily eliminate the use of CCA as a wood preservative for specified wood products by the end of 2003 may lead to an oversupply of arsenic trioxide until international producers adjust to the consequent decline in U.S. demand. In particular, arsenic trioxide production in China and Chile may ultimately be affected by the decline. However, there will still be a market for CCA-treated wood, especially for industrial applications such as marine timber, utility poles, and plywood roofing. Environmental considerations will continue to encourage the use of alternative wood preservatives, wood lumber alternatives, or concrete in place of CCA-treated wood.

The demand for arsenic metal in automobile batteries will decline as maintenance-free batteries replace conventional lead-acid storage batteries. Semiconductor manufacture will continue to require consumption of high-purity arsenic for production of gallium-arsenide semiconductors for telecommunications, automotive uses, solar cells, and military and space applications (European Microwave Week, 2002§; U.S. Department of Energy, 2003§). Arsenic metal will continue to be used in the production of ammunition and other alloys.

References Cited

Bohlen, J.T., 2003, Chemical warfare in Washington: Washington Post, April 27, p. B88.

Finkelman, R.B., 2000, Health impacts of coal combustion: U.S. Geological Survey Fact Sheet GS-094-00.

Groschen, G.E., Harris, M.A., King, R.B., Terrio, P.J., and Warner, K. L., 2001, Water quality in lower Illinois River Basin, Illinois, 1995-98: U.S. Geological Survey Circular 1209, 36 p.

Mau, D.P., 2001, Sediment deposition and trends and transport of phosphorus and other chemical constituents, Cheney Reservoir watershed, south-central Kansas: U.S. Geological Survey Water-Resources Investigations Report 01-4085, 40 p.

Planin, Eric, 2001, Deaths raise alarm on power plants: Washington Post, September 30, p. A2.

Reston Connection, 2003, Arsenic and old lake: Reston [VA] Connection, February 26, p. 3.

Rice, K.C., Conko, K.M., and Hornberger, G.M., 2002, Anthropogenic sources of arsenic and copper to sediments in a suburban lake, northern Virginia: Environmental Science and Technology, v. 36, no. 23, p. 4962-4967.

Richmond Times-Dispatch, 2001, Wood products to be labeled for arsenic: Richmond [VA] Times-Dispatch, July 4, p. A4.

Internet References Cited

Allen, Richard, 2000, Babbitt casting, accessed May 7, 2003, at URL http://www.steamengine.com.au/ic/faq/babbit.html.

Alpers, C.N., 2002, Mercury and arsenic contamination associated with abandoned mine lands, Bear River and South Yuba River watersheds—Coop portion of funding, accessed April 9, 2003, at URL http://ca.water.usgs.gov/projects00/ca553.html.

American Wood Preservers Institute, 2003, Manufacturers to transition to new generation of wood preservatives, accessed May 6, 2003, at URL http://www.preservewood.com/news/020212ccatrans.html.

Ayotte, J.C., 2000, Potential impact of regional geology on arsenic in ground water in New England, accessed May 8, 2003, at URL http://nh.water.usgs.gov/WhatsNews?newsreleases/arsenic.html.

Ayuso, R.A., and Foley, N.K., 2002, Arsenic in New England—Mineralogical and geochemical studies of sources and enrichment pathways, accessed April 9, 2003, at URL http://pubs.usgs.gov/of/2002/of02-454.

Bleiwas, D.I., 2003, Arsenic and old waste, accessed May 9, 2003, at URL http://minerals.usgs.gov/minerals/mflow/d00-0195.

Commonwealth of Pennsylvania Department of Environmental Protection, 1999, Utilization of wood residue, accessed May 21, 2003, at URL http://www.dep.state.pa.us/dep/SUBJECT/PUBS/oppca?FS2324.pdf.

European Microwave Week, 2002, European Gallium Arsenide and Other Semiconductors Application Symposium (GAAS 2002), accessed May 7, 2003, at URL http://www.eumw.com/gaas.html.

Hancock, T.C., Miller, C.V., Denver, J.M., Dover, D.E., and Riedel, G.F., 2003, Fate and transport of arsenical feed amendments in Chesapeake

Bay watersheds, accessed May 19, 2003, at URL http://va.water.usgs.gov/GLOBAL/Abst/hancock_setac_00.htm.
Health Canada, 2003, Update on the re-evaluation of copper chromated arsenate (CCA) treated wood in Canada, accessed April 4, 2003, at URL http://www.hc-sc.gc.ca/pmra-arla/english/pdf/rev/rev_2002-01-e.pdf.
Iowa Times Citizen, 2003, Buckeye meeting on arsenic, accessed June 4, 2003, at URL http://www.zwire.com/site/news.cfm?newsid=8192939&BRD=1813&PAG=461&dept_id=33843&rfi=6.
Konefes, J.L., and McGee, M.K., 1999, Old cemeteries, arsenic, and health safety, Cultural Resource Management Online, v. 19, no. 10, accessed June 5, 2003, at URL http://crm.cr.nps.gov/archive/19-10/19-10-6.pdf.
Osmose Holdings, Inc., 2002 (February 12), Osmose press release, accessed March 31, 2003, at URL http://www.osmose.com/wood/usa/cca_announcement/default/asp.
Robinson, G.R., Ayotte, J.D., Montgomery, D.L., and DeSimone, L.A., 2002, Lithogeochemical character of near-surface bedrock in the New England coastal basins, accessed April 9, 2003, at URL http://water.usgs.gov/pubs/of/ofr02-007/html/text.html.
St. Petersburg Times, 2001, EPA wants arsenic warnings on wood, accessed May 7, 2003, at URL http://www.sptimes.com/News?070401/Worldandnation/EPA_wants_arsenic_was.shtml.
Trex Company, Inc., 2003, Frequently asked questions, accessed April 7, 2003, at URL http://www.trex.com/universal/faq.asp.
U.S. Department of Energy, 2003, About photovoltaics and solar cell materials, accessed May 7, 2003, at URL http://www.eere.energy.gov/pv/gallium.html.
U.S. Environmental Protection Agency, 2001, Arsenic in drinking water, accessed May 7, 2003, at URL http://epa.gov/safewater/arsenic.html.
U.S. Geological Survey, 1998, China and U.S. Geological Survey working together on environmental issues, News Release, accessed May 8, 2003, at URL http://www.usgs.gov/public/press/public_affairs/press_releases/pr565m.html.
Welch, A.H., Westjohn, D.B., Helsel, D.R., and Wanty, R.B., 2000, Arsenic in ground water of the United States—Occurrence and chemistry, Ground Water, v. 38, no. 4, accessed April 9, 2002, at URL http://co.water.usgs.gov/trace/pubs/gw_v38n4.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Arsenic. Ch. in Mineral Commodity Summaries, annual.
Arsenic. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
Gallium. Ch. in Minerals Yearbook, annual.

Other

1996 Wood Preserving Industry Production Statistical Report. American Wood Preserving Institute, 1998.
American Wood Preserving Institute, Reston, VA.
Arsenic (8th ed.). Roskill Information Services Ltd., 1992.
Gallium and Gallium Arsenide—Supply, Technology, and Uses. U.S. Bureau of Mines Information Circular 9208, 1988.
Materials Flow of Arsenic in the United States, The. U.S. Bureau of Mines Information Circular 9382, 1994.

TABLE 1
ARSENIC SUPPLY-DEMAND RELATIONS[1]

(Metric tons, arsenic content)

	1998	1999	2000	2001	2002
U.S. supply:					
Imports, metal	997	1,300	830	1,030	879
Imports, compounds	29,300	22,100	23,600	23,900	18,800
Total	30,300	23,400	24,500	25,000	19,700
Distribution of U.S. supply:					
Exports[2]	177	1,350	41	57	100
Apparent demand	30,100	22,000	24,400	24,900	19,600
Estimated U.S. use:					
Agricultural chemicals	1,200 r	850 r	950 r	1,000 r	750
Glass	900 r	600 r	700	750 r	700
Wood preservatives	26,500 r	19,500 r	21,800 r	21,900 r	17,300
Nonferrous alloys and electronics	1,200 r	850 r	700 r	1,000	650
Other	300	200 r	250 r	250 r	200
Total	30,100	22,000	24,400 r	24,900 r	19,600

rRevised.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Metal only.

TABLE 2
U. S. IMPORTS FOR CONSUMPTION OF ARSENIC PRODUCTS[1]

Class and country	2001 Quantity (metric tons)	2001 Value (thousands)	2002 Quantity (metric tons)	2002 Value (thousands)
Arsenic trioxide:				
Belgium	193	129	205	136
Bolivia	120	68	60	34
Chile	5,110	2,070	2,160	958
China	17,800	9,250	16,800	8,330
France	319	210	--	--
Germany	18	20	16	59
Hong Kong	344	163	516	261
Mexico	1,810	1,120	688	495
Morocco	5,800	2,850	4,210	2,330
Total	31,500	15,900	24,700	12,600
Arsenic acid, Canada	2	3	1	4
Arsenic sulfide, Canada	(2)	5	--	--
Arsenic metal:				
Chile	79	84	--	--
China	741	1,220	733	1,710
France	(2)	3	--	--
Germany	6	1,210	3	535
Hong Kong	58	51	--	--
Japan	143	4,730	144	1,140
Singapore	1	62	--	--
United Kingdom	2	34	(2)	5
Total	1,030	7,390	879	3,390

-- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Less than 1/2 unit.

Source: U.S. Census Bureau.

TABLE 3
ARSENIC TRIOXIDE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2, 3]

(Metric tons)

Country[4]	1998	1999	2000	2001	2002
Belgium	1,500	1,500	1,500	1,000	1,000
Bolivia	284 [5]	437 [5]	318 [5]	846 [r, 5]	850
Canada	250	250	250	250	250
Chile	8,400 [5]	8,000	8,000	8,000	8,000
China	15,500	16,000	16,000	16,000	16,000
France	2,000	1,000	1,000	1,000	1,000
Georgia	400	-- [r]	-- [r]	-- [r]	--
Germany	200	200	200	100	100
Ghana[6]	5,000 [5]	7,000	3,000	--	--
Iran	323 [5]	300	400	400	400
Japan	40	40	40	40	40
Kazakhstan	1,500	1,500	1,500	1,500	1,500
Mexico	2,573 [5]	2,419 [5]	2,522 [5]	2,381 [r, 5]	2,300
Namibia	175 [5]	-- [5]	--	--	--
Peru[7]	624 [5]	1,611 [5]	2,495 [5]	1,958 [r, 5]	2,000
Portugal	50	50	50	50	50
Russia	1,500	1,500	1,500	1,500	1,500
Total	40,300	41,800 [r]	38,800 [r]	35,000 [r]	35,000

[r]Revised. -- Zero.

[1]Including calculated arsenic trioxide equivalent of output of elemental arsenic compounds other than arsenic trioxide where inclusion of such materials would not duplicate reported arsenic trioxide production.

[2]World totals and estimated data have been rounded to no more than three significant digits; may not add to totals shown.

[3]Table includes data available through April 1, 2003.

[4]Austria, Hungary, the Republic of Korea, Serbia and Montenegro, South Africa, Spain, the United Kingdom, and Zimbabwe produced arsenic and/or arsenic compounds in previous years, but information is inadequate to make estimates of output levels, if any.

[5]Reported.

[6]Production ceased in mid-2000. Ashanti Goldfields Ltd. Obuasi roaster closed.

[7]Output of Empresa Minera del Centro del Perú (Centromín Perú) as reported by the Ministerio de Energía y Minas.