PERU MERCURY INVENTORY 2006

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Conversion Factors

Multiply	By	To obtain
centimeter (cm)	0.3937	inch (in.)
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.204	pounds
kilograms per year (kg/yr)	2.204	pounds per year
kilometer (km)	0.6214	mile (mi)
liter (L)	33.82	ounce, fluid (fl. oz)
meter (m)	3.281	foot (ft)
metric ton (t)	1.10231	short ton
metric ton per year (t/yr)	1.102	ton per year (ton/yr)
square kilometer (km^2)	247.1	acre

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$°F=(1.8\times°C)+32$

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Abstract

In 2004, a specific need for data on mercury use in South America was indicated by the United Nations Environmental Programme-Chemicals (UNEP-Chemicals) at a workshop on regional mercury pollution that took place in Buenos Aires, Argentina. Mercury has long been mined and used in South America for artisanal gold mining and imported for chlor-alkali production, dental amalgam, and other uses.

The U.S. Geological Survey (USGS) provides information on domestic and international mercury production, trade, prices, sources, and recycling in its annual Minerals Yearbook mercury chapter. Therefore, in response to UNEP-Chemicals, the USGS, in collaboration with the Economic Section of the U.S. Embassy, Lima, has herein compiled data on Peru's exports, imports, and byproduct production of mercury. Peru was selected for this inventory because it has a 2000-year history of mercury production and use, and continues today as an important source of mercury for the global market, as a byproduct from its gold mines. Peru is a regional distributor of imported mercury and user of mercury for artisanal gold mining and chlor-alkali production.

Peruvian customs data showed that 22 metric tons (t) of byproduct mercury was exported to the United States in 2006. Transshipped mercury was exported to Brazil (1 t), Colombia (1 t), and Guyana (1 t). Mercury was imported from the United States (54 t), Spain (19 t), and Kyrgyzstan (8 t) in 2006 and was used for artisanal gold mining, chlor-alkali production, dental amalgam, or transshipment to other countries in the region. Site visits and interviews provided information on the use and disposition of mercury for artisanal gold mining and other uses.

Peru also imports mercury-containing batteries, electronics and computers, fluorescent lamps, and thermometers. In 2006, Peru imported approximately 1,900 t of a wide variety of fluorescent lamps; however, the mercury contained in these lamps, a minimum of approximately 76 kilograms (kg), and in other products such as batteries and computer electronics is not recycled and may ultimately be released to the environment.

Introduction

Throughout history, mercury has been known and used for gold and silver processing. In Peru and many parts of the world, mercury is now used in batteries, chlor-alkali production, dental amalgam, fluorescent lights, switches, and thermometers. Much of the mercury contained in these end-of-use products can be recycled (Brooks and Matos, 2005); however, only a small amount of the mercury used for artisanal gold mining is recycled.

Mercury, the liquid metal, occurs naturally in a number of geologic environments, may be obtained as a byproduct from precious metals mining, or is found in trace amounts in coal. Much of this mercury may be used and recycled; however, mercury used for artisanal gold production and mercury released from coal-fired powerplants, broken fluorescent lamps, and other sources is not recovered and becomes a global environmental and human health concern.

In 2001, the Global Environment Facility allocated funding for studies related specifically to mercury use for artisanal gold mining in six countries from three continents. In order to focus awareness on human health issues, mercury releases, and regional mercury pollution, a United Nations Environmental Programme-Chemicals (UNEP-Chemicals) workshop took place in Buenos Aires, Argentina, in 2004. UNEP-Chemicals indicated a specific need for data and information on mercury production and use of mercury for artisanal gold mining in South America. Minimizing mercury contamination in the Amazon Basin was the theme of meetings held in Rio de Janeiro, Brazil, in December 2004 and in Lima, Peru, in February 2005. Sources of contamination, ecotoxicity, and human health issues were discussed by attendees from Bolivia, Brazil, Colombia, Ecuador, Peru, Suriname, and Venezuela. These meetings were sponsored by the Amazon Cooperation Treaty Organization (Brazil), the Andean Community (Peru), the Ministry of Environment (Brazil), and the Regional Environmental Program of the Department of State-U.S. Embassy, Brasilia, Brazil.

In 2006, Peru ranked first in gold production in Latin America and fifth in world gold production as well as being a world leader in silver, zinc, copper, and tin production. Therefore, because of environmental awareness and mercury stewardship on the part of Peru's major international mining companies, Peru became a leader in reduction of mercury emissions and byproduct mercury recovery from their large scale open-pit mines (Barrick Gold Corporation, 2005, p. 14). Byproduct mercury and calomel (Hg_2Cl_2), which is recovered from precious metals processing in Peru and elsewhere in South America, are exported to the United States for processing, and the mercury is resold into the world market, where it may be used for a variety of uses. Peru also imports mercury for artisanal mining, chlor-alkali production, and dental amalgam. Mercury is also imported as a component of batteries, electronics, fluorescent lamps, medical equipment, and thermometers.

The U.S. Embassy, Lima requested an in-country, field inventory of commodity mercury in Peru through the U.S. Department of State's Embassy Science Fellow Program. This was in response to the need for mercury information in the region indicated by UNEP-Chemicals at environmental meetings in Rio de Janiero and Lima, and Peru's leading role in gold mining, byproduct production of mercury, and widespread use of mercury for artisanal gold mining in Peru.

Ancient Use of Mercury

Mercury and the ore of mercury, cinnabar, were known to and used by ancient people in Asia, Europe, and South America. Geologically, mercury and cinnabar are well-known at Almaden, Spain; Huancavalica, Peru; Idrija, Slovenia; in the Yangtze belt, China; and other locations. Archaeologists have shown that mercury was used for gold amalgamation by the Romans, and cinnabar was used for funeral preparations and as a multi-use pigment.

Near Valencia, Spain, well-preserved human bones covered with powdered cinnabar were found in a tomb that dates to 5000 B.C. (Maravelaki-Kalaitzaki and Kallithrakas-Kontos, 2003). Mercury was found in a ceremonial cup in an Egyptian tomb that dates to 1600 B.C. and the Greeks retorted mercury from cinnabar in 300 B.C. Archaeologists have described an underground tomb in China that dates to 200 B.C. and it is described as having flowing rivers of mercury (China History Forum, 2006; Saiget, 2007). Roman villas were decorated with pigments made from powdered cinnabar, which was also used for makeup and, by A.D. 77, 4 to 5 t of mercury were imported annually from the mines in Spain for gold amalgamation. Roman slaves and criminals were sent to work, and subsequently to die, from the toxic mercury fumes released by firesetting (an ancient mining practice in which wood was burned at the face of the ore zone and water was poured on the face causing the rock to spall and crack) in the Spanish mercury mines (D'Itri and D'Itri, 1977, p. 6). In Central America, jade and shell fragments were found floating on a tiny, approximately 130-gram (g) pool of mercury in a closed container in a Mayan tomb in Belize that dates to A.D. 900-1000 (Pendergast, 1982).

Mercury was known in ancient Peru and used by the Moche (approximately 100 B.C.-A.D. 750) in northern Peru to amalgamate placer gold and for the production of gold artifacts (Kaufmann Doig, 1978,

p. 747; Larco Hoyle, 2001, p. 128). Mercury was recovered from drainages near the mercury occurrences at Huancavelica, and possibly from retorting cinnabar (Petersen, 1970, p. 55). Whether or not the ancient Andeans retorted cinnabar for mercury is controversial; however, retorts have been identified near the mines at Huancavelica (K. Brown, professor, Brigham Young University, written commun., May 9, 2003). Powdered cinnabar was used to decorate gold masks during the Formative Period (400-1000 B.C.) (De Lavalle, 1992, p. 39); as a mineral pigment used on murals (Muelle and Wells, 1939, p. 27; Brooks and others, 2006b); for painting warriors bodies and as a cosmetic for the elite Inca women (Brown, 2001, p. 477); and also for funeral preparations (Maravelaki-Kalaitzaki and Kallithrakas-Kontos, 2003; Jackson, 2004; J. Verano, Ph.D., anthropologist, Dumbarton Oaks, Washington, D.C., oral commun., December 12, 2005).

Approximately 20 mercury occurrences are known in Peru (Petersen, 1970, p. 55) and there are occurrences in southern Ecuador, near Cuenca and Azoguines (Truhan and others, 2005); however, the occurrences at Huancavelica are the largest and most well-known in the region and are the most likely source of mercury and cinnabar used in the ancient Andes. Only 15 kilometers (km) from the mine is Atalla, an archaeological site which was interpreted as an ancient cinnabar pigment production center (Burger and Matos, 2002, p. 10). As did the Romans, the Inca recognized the health hazards of mercury and that exposure to mercury and cinnabar during mining and retorting would cause the ancient miners “to shake and lose their senses” and, therefore, the use of mercury by the Inca declined (Larco Hoyle, 2001, p. 135).

Originally, Spain transported mercury from the mines at Almaden for mineral processing in the New World, and Spanish shipwrecks that still contain mercury are known in the Dominican Republic and in Colombia (Petersen, 1979, p. 851). However, upon re-discovery of the mercury occurrences at Huancavelica by the Europeans in the 1600s (Arana, 1901, p. 77), this regional source soon replaced imported Spanish mercury. Because of the combination of dangerous mining conditions, cold, working at 4,000 meters (m), and exposure to the toxic mercury fumes, Huancavelica was known as the “mina de la muerte” [the mine of death] (Brown, 2001, p. 468). Regardless, mercury’s role was important for mineral processing in Spanish Colonial Peru and adding mercury, “el azogado” [azogue is an Arabic term for mercury that is commonly used in many parts of Latin America], was an essential step in silver recovery (Del Busto Duthurburu, 1996, p. 98).

Mercury from Huancavelica was also used in the “patio process” for silver processing in Chile, Bolivia, and Mexico. Salt, mercury, and vitriol (mixed copper and iron sulfates) were mixed with crushed silver ore that contained argentite (Ag_2S), cerargyrite (AgCl), or pyragyrite (Ag_3SbS_3), also known as the “dry ores,” in a large open area, or patio, and at Potosí, Bolivia, the cold climate required that the patios be heated from below to speed silver production (Craddock, 1995, p. 216).

Mercury in Coal