United States
Environmental Protection
Agency

Office of Water
4601

EPA 811-F-95-002a-T
October 1995

EPA

National Primary Drinking Water Regulations

Asbestos

CHEMICAL/ PHYSICAL PROPERTIES

CAS NUMBER: 1332-21-4

COLOR/ FORM/ODOR: White, gray, green or brown crystalline fibers; odorless

SOLUBILITIES: insoluble

SOIL SORPTION COEFFICIENT: N/A

BIOCONCENTRATION FACTOR: N/A; not expected to bioconcentrate

COMMON ORES: Amosite, Chrysotile, Crocidiolite; Tremolite; Ascarite

DRINKING WATER STANDARDS

MCLG: 7 million fibers per liter (MFL) (fibers > 10 microns in length)

MCL: 7 million fibers per liter (MFL)

HAL(child): none

HEALTH EFFECTS SUMMARY

Acute: No reliable data are available on the acute toxic effects from short-term exposures to asbestos. No Health Advisories have been established for short-term exposures.

Chronic: Asbestos has the potential to cause lung disease from a lifetime exposure at levels above the MCL.

Cancer: Asbestos has the potential to cause cancer of the lung and other internal organs from a lifetime exposure at levels above the MCL.

USAGE PATTERNS

Because asbestos fibers are resistant to heat and most chemicals, they have been mined for use in a variety of products (over 3,000 different products in the United States). In 1988, asbestos was consumed in roofing products, 28%; friction products, 26%; asbestos cement pipe, 14%; packing and gaskets, 13%; paper, 6%; and other 13%.

Pipe products find use in water supply, sewage disposal, & irrigation systems. Asbestos cement sheets are used in a wide variety of construction applications. Other uses of asbestos include fire resistant textiles, friction materials (ie, brake linings), underlayment & roofing papers, & floor tiles, Crocidolite can be spun & woven using modified cotton industry machinery; the asbestos cloth is used for fireproof clothing & curtains.

Most uses of asbestos were banned in the United States by the EPA on July 12, 1989 because of potential adverse health effects in exposed persons. The remaining, currently allowed uses of asbestos include battery separators, sealant tape, asbestos thread, packing materials, and certain industrial uses of both sheet gaskets and beater-add gaskets.

RELEASE PATTERNS

Asbestos fibers may enter the environment from natu-

TOXIC RELEASE INVENTORY - RELEASES TO WATER AND LAND: 1987 TO 1993

	Water	Land
TOTALS (in pounds)	32,650	8,620,439
Top Five States		
PA	0	2,945,049
LA	61	2,256,400
TX	0	1,737,200
AR	1,000	568,227
VA	0	480,000
Top Industrial Sources		
Asbestos products	3,005	2,510,227
Alkalis, chlorine	1,973	2,256,404
Industrial organic chems	0	1,230,000
Asphalt felts, coatings	5	871,067
Auto parts	0	563,694
Petroleum refining	0	314,560
Plastic pipes	0	235,200
Shipbuilding, repairing	0	211,400

* State/Industry totals only include facilities with releases greater than a certain amount - usually 1000 to 10,000 lbs.

ral sources such as erosion of asbestos-containing ores, but the primary source of asbestos in the environment is through the wear or breakdown of asbestos-containing materials. Asbestos fibers have been released into water by the dumping of mining tailings into lakes, by the runoff of process and air scrubber water into lakes and streams, and by the use of asbestos cement pipes in water supply systems.

Over one million tons of asbestos is contained in friable materials in ships, buildings, power plants, chemical plants, refineries, and other locations of high temperature equipment. Other products may include insulation, automobile brakes, cement pipes, and roofing materials. The maintenance, repair, and removal of this material will account for the principal releases in the future. Asbestos fibers also can be released to the environment from asbestos processing, including milling, manufacturing, and fabrication.

From 1987 to 1993, according to the Toxics Release Inventory, asbestos releases to land totalled nearly 9 million lbs., and releases to water totalled nearly 33,000 lbs. These releases were primarily from asbestos products industries which use asbestos in roofing materials friction materials, and cement. The largest releases occurred in Pennsylvania and Louisiana.

ENVIRONMENTAL FATE

As a naturally occurring substance, asbestos can be present in surface and ground water. Because asbestos fibers in water do not evaporate into air or break down in water, small fibers and fiber-containing particles may be carried long distances by water currents before settling to the bottom; larger fibers and particles tend to settle more quickly.

Asbestos does not tend to adsorb to solids normally found in natural water systems, but some materials (trace metals and organic compounds) have an affinity for asbestos minerals. The fibers are not able to move down through soil to ground water.

Asbestos is not affected by photolytic processes and is considered to be non-biodegradable by aquatic organisms. Asbestos fibers are not broken down to other compounds in the environment and, therefore, can remain in the environment for decades or longer.

There are no data regarding the bioaccumulation of asbestos in aquatic organisms.

OTHER REGULATORY INFORMATION

MONITORING:

- FOR GROUND AND SURFACE WATER SOURCES:
  - INITIAL FREQUENCY- 1 sample once every 9 years
  - REPEAT FREQUENCY- 1 sample once every 9 years
- TRIGGERS - If detect at > 7 MFL, sample quarterly.

ANALYSIS:

REFERENCE SOURCE	METHOD NUMBERS
EPA 800/4-83-043	Transmission Electron Microscopy

TREATMENT:

BEST AVAILABLE TECHNOLOGIES

Coagulation/Filtration; Direct and Diatomite Filtration; Corrosion Control

FOR ADDITIONAL INFORMATION:

♦ EPA can provide further regulatory and other general information:
- EPA Safe Drinking Water Hotline - 800/426-4791

♦ Other sources of toxicological and environmental fate data include:
- Toxic Substance Control Act Information Line - 202/554-1404
- Toxics Release Inventory, National Library of Medicine - 301/496-6531
- Agency for Toxic Substances and Disease Registry - 404/639-6000

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National Primary Drinking Water Regulations

Barium

CHEMICAL/ PHYSICAL PROPERTIES

CAS NUMBER: 7440-39-3 (metal)
COLOR/ FORM/ODOR: Barium is a lustrous, machinable metal which exists in nature only in combined form.
SOIL SORPTION COEFFICIENT: Koc N/A; high mobility
BIOCONCENTRATION FACTOR: BCFs of 7-100 for marine animals, 1000 for marine plants, 2-20 for some crops.
COMMON ORES: sulfate- Barite; carbonate- Witherite

SOLUBILITIES (WATER):

carbonate-	22 mg/L at 18 deg C
chloride-	310 g/L at 0 deg C
chromate-	3.4 mg/L at 16 deg C
cyanide	800 g/L at 14 deg C
hydroxide-	sol. in dil. acid
nitrate-	87 g/L at 20 deg C
permanganate-	625 g/L at 11 deg C
peroxide-	sol. in dil. acid
sulfate-	2.2 mg/L at 18 deg C

DRINKING WATER STANDARDS

MCLG:	2 mg/l
MCL:	2 mg/l
HAL(child):	none

HEALTH EFFECTS SUMMARY

Acute: EPA has found barium to potentially cause gastrointestinal disturbances and muscular weakness resulting from acute exposures at levels above the MCL.

No Health Advisories have been established for short-term exposures.

Chronic: Barium has the potential to cause hypertension resulting from long-term exposures at levels above the MCL.

Cancer: There is no evidence that barium has the potential to cause cancer from lifetime exposures in drinking water.

USAGE PATTERNS

The largest end use of barium metal is as a "getter" to remove the last traces of gases from vacuum and television picture tubes. It is also used to improve performance of lead alloy grids of acid batteries; as a component of grey and ductile irons; in the manufacture of steel, copper and other metals; as a loader for paper, soap, rubber and linoleum.

Barium peroxide is used as a bleach, in dyes, fireworks and tracer-bullets, in igniter and welding materials, and in manufacture of hydrogen peroxide and oxygen. The permanganate is used as a dry cell depolarizer and in disinfectants.

Barium nitrate is used in fireworks, ceramic glazes, electronics, tracer bullets, detonators, and neon sign lights. Barium cyanide is used in electroplating and metallurgy. Barium chlorate is used in fireworks, explosives, matches, and as a mordant in dyeing.

Barium carbonate is used as follows: 45 percent as ingredient in glass, 25 percent in brick and clay products, 7 percent as a raw material for barium ferrites, 4 percent in photographic paper coatings, 19 percent other.

TOXIC RELEASE INVENTORY - RELEASES TO WATER AND LAND: 1987 TO 1993

	Water	Land
TOTALS (in pounds)	928,448	57,063,031
Top Ten States*		
AZ	0	14,595,520
UT	1,500	13,423,164
VA	0	9,218,901
NM	0	5,233,790
IL	34,000	3,977,817
TN	0	2,586,906
AL	31,041	1,638,988
PA	15,582	1,216,362
TX	167,864	599,565
NJ	20,905	705,666
Major Industries*		
Copper smelting	1,500	31,958,310
Car parts, accessories	1,743	9,456,667
Industrial organics	132,511	4,106,827
Inorganic pigments	5,261	3,672,451
Gray, ductile iron	0	1,556,681
Steelworks, furnaces	256,582	679,999
Electrometallurgy	1,599	633,876
Paper mills	64,770	527,330

* Water/Land totals only include facilities with releases greater than a certain amount - usually 1000 to 10,000 lbs.

Barium hydroxide is used in lubricating oils and greases and as a component of detergents in motor oils. It is also used in plastics stabilizers, papermaking additives, sealing compounds, vulcanization accelerators, pigment dispersants and self-extinguishing polyurethane foams and to protect limestone objects from deterioration.

Barium chloride is used in pigments, glass, dyeing, leather tanning, chlorine and sodium hydroxide manufacture and in water softening. Barium-based dyes are widely used in inks, paints, cosmetics and drugs

Over 65% of barite produced was used as a weighting agent in oil and gas well drilling fluids, with a 50 percent decrease in demand for barite in 1986 due primarily to a severe downturn in oil and gas well drilling activity prompted by soft world oil prices. Barium sulfate is also used in photographic papers, pigments and as a filler for rubber & resins.

RELEASE PATTERNS

Barium metal does not occur in nature. The most common ores are the sulfate, barite, found in AK, AR, CA, GA, KY, MO, NV, TN, and the carbonate, witherite, found in AR, CA, GA, KY, MO, NV. Barite was produced at 38 mines in the seven states in 1973, with Nevada supplying 50% of the tonnage. Missouri ranked second.

Barium is released to water and soil in the discharge and disposal of drilling wastes, from the smelting of copper, and the manufacture of motor vehicle parts and accessories.

Barium is emitted into the atmosphere mainly by the industrial processes involved in the mining, refining, and production of barium and barium-based chemicals, and as a result of combustion of coal and oil.

From 1987 to 1993, according to the Toxics Release Inventory barium compound releases to land and water totalled over 57 million lbs., of which about 99 percent was to land. These releases were primarily from copper smelting industries which use barium as a deoxidizer. The largest releases occurred in Arizona and Utah. The largest direct releases to water occurred in Texas

Barium is found in waste streams from a large number of manufacturing plants in quantities that seldom exceed the normal levels found in soil. Background levels for soil range from 100-3000 ppm barium. Occurs naturally in almost all (99.4%) surface waters examined, in concentration of 2 to 340 ug/l, with an average of 43 ug/l. The drainage basins with low mean concentration of barium (15 ug/l) occur in the western Great Lakes, & the highest mean concentration of 90 ug/l is in the southwestern drainage basins of the lower Mississippi Valley. In stream water & most groundwater, only traces of the element are present.

There are limited survey data on the occurrence of barium in drinking water. Most supplies contain less than 200 ug/l of barium. The average concentration of barium in USA drinking water is 28.6 ug/l (1977 data). The drinking water of many communities in Illinois, Kentucky, Pennsylvania, & New Mexico contains concentrations of barium that may be 10 times higher than the drinking water standard. The source of these supplies is usually well water. Currently 60 ground water supplies and 1 surface water supply exceeds 1000 ug/l.

ENVIRONMENTAL FATE

In water, the more toxic soluble barium salts are likely to precipitate out as the less toxic insoluble sulfate or carbonate. Barium is not very mobile in most soil systems. Adsorption of barium was measured in a sandy soil and a sandy loam soil at levels closely corresponding to those to be expected for field conditions. In general, sludge solutions appeared to increase the mobility of elements in a soil. This is due to a combination of complexation by dissolved organic compounds, high background concentration and high ionic strengths of the soil solution.

Marine animals concentrate the element 7-100 times, and marine plants 1000 times from seawater. Soybeans and tomatoes also accumulate soil barium 2-20 times.

OTHER REGULATORY INFORMATION

MONITORING:

- **FOR GROUND WATER SOURCES:**
  - **INITIAL FREQUENCY-** 1 sample once every 3 years
  - **REPEAT FREQUENCY-** If no detections for 3 rounds, once every 9 years
- **FOR SURFACE WATER SOURCES:**
  - **INITIAL FREQUENCY-** 1 sample annually
  - **REPEAT FREQUENCY-** If no detections for 3 rounds, once every 9 years
- **TRIGGERS** - If detect at > 2 mg/L, sample quarterly.

ANALYSIS:

REFERENCE SOURCE	METHOD NUMBERS
EPA 600/4-79-020	208.1; 208.2
NTIS PB 91-231498	200.7
Standard Methods	3111D; 3113B

TREATMENT:

BEST AVAILABLE TECHNOLOGIES

Ion Exchange, Reverse Osmosis, Lime Softening, Electrodialysis

FOR ADDITIONAL INFORMATION:

♦ EPA can provide further regulatory and other general information:

- EPA Safe Drinking Water Hotline - 800/426-4791

♦ Other sources of toxicological and environmental fate data include:

- Toxic Substance Control Act Information Line - 202/554-1404
- Toxics Release Inventory, National Library of Medicine - 301/496-6531
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Cadmium

CHEMICAL/ PHYSICAL PROPERTIES

CAS NUMBER: 7440-43-9 (metal)

COLOR/ FORM/ODOR: Cadmium is a lustrous silvery metallic element found only in combined forms in nature.

SOIL SORPTION COEFFICIENT: Koc = N/A; mobility higher than other metals

BIOCONCENTRATION FACTOR: Fish: 33 to 2213; Shell fish: 5 to 2500; Other invertebrates: 164 to 4190; Plants: 603 to 960.

COMMON ORES: sulfide- greenockite; carbonate- octavite; others: hawleyite. Also found in zinc, copper, lead ores.

SOLUBILITIES (WATER):

acetate-	very soluble
bromide-	570 g/L at 10 deg C
carbonate-	insoluble
chloride-	1400 g/L at 20 deg C
fluoroborate-	very soluble
mercury sulfide-	N/A
nitrate-	1090 g/L at 0 deg C
oxide-	insoluble
sulfate-	755 g/L at 0 deg C
sulfide-	insoluble
stearate-	N/A

DRINKING WATER STANDARDS

MCLG: 0.005 mg/l

MCL: 0.005 mg/l

HAL(child): 1- to 10-day: 0.04 mg/L
Longer-term: 0.005 mg/L

HEALTH EFFECTS SUMMARY

Acute: EPA has found cadmium to potentially cause a variety of effects from acute exposures, including: nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock and renal failure.

Drinking water levels which are considered "safe" for short-term exposures: For a 10-kg (22 lb.) child consuming 1 liter of water per day, a one- to ten-day exposure to 0.04 mg/L; a longer-term (up to 7 years) exposure to 0.005 mg/L.

Chronic: Cadmium has the potential to cause kidney, liver, bone and blood damage from long- term exposure at levels above the MCL.

Cancer: There is inadequate evidence to state whether or not cadmium has the potential to cause cancer from lifetime exposures in drinking water.

USAGE PATTERNS

2.9 million lbs of cadmium were produced in the US in 1986, and nearly twice that amount was imported in the same year.

According to 1986 estimates, cadmium is used primarily for metal plating and coating operations (35%), including transportation equipment, machinery and baking enamels, photography, television phosphors. It is also used in nickel-cadmium and solar batteries (25%), in pigments (20%), as a stabilizer in plastics and synthetic products (15%), alloys and other uses (5%). Cadmium salts have had a very limited use as fungicide for golf courses and home lawns.

RELEASE PATTERNS

Cadmium occurs naturally in zinc, lead and copper ores, in coal and other fossil fuels, shales and is released

TOXIC RELEASE INVENTORY - RELEASES TO WATER AND LAND: 1987 TO 1993

	Water	Land
TOTALS (in pounds)	31,487	2,059,574
Top Seven States*		
AZ	503	433,035
UT	1,750	372,010
MT	0	315,965
TN	2,700	288,781
ID	250	225,761
MO	2,361	189,914
WI	0	106,000
Major Industries*		
Zinc, lead smelting	5,061	831,948
Copper smelting, refining	2,253	805,045
Indust. inorganic chems	250	225,761
Electroplating, anodizing	0	106,000
Steelworks, blast furnaces	5	13,000
Inorganic pigments	5,140	7,000

* State/Industry totals only include facilities with releases greater than a certain amount - usually 1000 to 10,000 lbs.

during volcanic action. These deposits can serve as sources to ground and surface waters, especially when in contact with soft, acidic waters.

Major industrial releases of cadmium are due to wastestreams and leaching of landfills, and from a variety of operations that involve cadmium or zinc. These may include: during the smelting and refining of zinc, lead and copper bearing ores; during recovery of metal by processing scrap; during melting and pouring of cadmium metal; during casting of various cadmium alloy products used for coating telephone cables, trolley wires, welding, electrodes, automatic sprinkling systems, steam boilers, fire alarms, high pressure/temperature bearings, starting switches, aircraft relays, light duty circuit breakers, low temperature solder, and jewelry; during fabrication of metal, alloys, or plated steel; during casting and use of solders; during melting of cadmium ingots for paint and pigment manufacture used for coloring of plastics and ceramic glazes, electroplating, and in chemical synthesis; during coating of metals by hot dipping or spraying; during manufacture of nickel-cadmium batteries for use in radio portable telephones, convenience appliances, and vented cells used in airplanes, helicopters, and stand-by power and lighting. The remaining cadmium emissions are from fossil fuel combustion, fertilizer application, and sewage sludge disposal.

Cadmium also occurs as a by-product of corrosion of some galvanized plumbing and distribution system materials.

From 1987 to 1993, according to EPA's Toxic Chemical Release Inventory, cadmium releases were primarily from zinc, lead and copper smelting and refining industries, with the largest releases occurring in Arizona and Utah.

ENVIRONMENTAL FATE

The oxide and sulfide are relatively insoluble while the chloride and sulfate salts are soluble. The adsorption of cadmium onto soils and silicon or aluminum oxides is strongly pH-dependent, increasing as conditions become more alkaline. When the pH is below 6-7, cadmium is desorbed from these materials. Cadmium has considerably less affinity for the absorbents tested than do copper, zinc, and lead and might be expected to be more mobile in the environment than these materials.

Studies have indicated that cadmium concentrations in bed sediments are generally at least an order of magnitude higher than in overlying water. A study of Ottawa River sediments found that sediment composed mainly of well sorted sand may be an efficient sink for heavy metals if there is a significant amount of organic material added to the sediments by the commercial activities such as logging. Both sorption and desorption were controlled by the nature of total heavy metal loading, the sediment type, and the surface water characteristics.

Addition of anions, such as humate, tartrate, to dissolved cadmium caused an increase in adsorption. The mode by which cadmium is sorbed to the sediments is important in determining its disposition toward remobilization.

Cadmium found in association with carbonate minerals, precipitated as stable solid compounds, or co-precipitated with hydrous iron oxides would be less likely to be mobilized by resuspension of sediments or biological activity. Cadmium absorbed to mineral surfaces (eg clay) or organic materials would be more easily bioaccumulated or released in the dissolved state when sediments are disturbed, such as during flooding.

Cadmium is not known to form volatile compounds in the aquatic environment.

Bioconcentration of cadmium sulfate, nitrate and chloride has been studied in a wide variety of aquatic organisms, and can be quite high in some species, low in others. For example, rainbow trout have a BCF of 33 while a BCF of 2213 was measured in the mosquito fish. Similarly, different species of clams have BCFs ranging from 160 to 3770.

OTHER REGULATORY INFORMATION

MONITORING:

- FOR GROUND WATER SOURCES:
  - INITIAL FREQUENCY- 1 sample once every 3 years
  - REPEAT FREQUENCY- If no detections for 3 rounds, once every 9 years
- FOR SURFACE WATER SOURCES:
  - INITIAL FREQUENCY- 1 sample annually
  - REPEAT FREQUENCY- If no detections for 3 rounds, once every 9 years
- TRIGGERS - If detect at > 0.005 mg/L, sample quarterly.

ANALYSIS:

REFERENCE SOURCE	METHOD NUMBERS
EPA 600/4-79-020	213.2
NTIS PB 91-231498	200.7
Standard Methods	3113B

TREATMENT

BEST AVAILABLE TECHNOLOGIES

Coagulation/Filtration, Ion Exchange, Lime Softening, Reverse Osmosis

FOR ADDITIONAL INFORMATION:

♠ EPA can provide further regulatory and other general information:
- EPA Safe Drinking Water Hotline - 800/426-4791

♠ Other sources of toxicological and environmental fate data include:
- Toxic Substance Control Act Information Line - 202/554-1404
- Toxics Release Inventory, National Library of Medicine - 301/496-6531
- Agency for Toxic Substances and Disease Registry - 404/639-6000

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Chromium

CHEMICAL/ PHYSICAL PROPERTIES

CAS NUMBER: 7440-47-3

COLOR/ FORM/ODOR: Chromium is metal found in nature only in the combined state.

SOIL SORPTION COEFFICIENT: N/A; Low mobility

BIOCONCENTRATION FACTOR: BCF in plants, 1000; in snails, 1,000,000; expected to accumulate in aquatic organisms.

COMMON ORES: oxide- Iron chromite

SOLUBILITIES:

chloride-	soluble in cold water
chromate-	0.2 mg/L (lead salt)
chromate-	873 g/L at 30 deg C (sodium salt)
chromate oxide-	insoluble
dichromate-	2380 g/L at 0 deg C (sodium salt)
dioxide-	insoluble
oxide-	insoluble
sulfate-	insoluble
trioxide-	617 g/L at 0 deg C

DRINKING WATER STANDARDS

MCLG:	0.1 mg/l
MCL:	0.1 mg/l
HAL(child):	1- to 10-day: 1 mg/L
	Longer-term: 0.2 mg/L

Note: These standards are based on the total concentration of the trivalent and hexavalent forms of dissolved chromium (Cr^{3+} and Cr^{6+}).

HEALTH EFFECTS SUMMARY

Acute: EPA has found chromium to potentially cause the following health effects from acute exposures at levels above the MCL: skin irritation or ulceration.

Drinking water levels which are considered "safe" for short-term exposures: For a 10-kg (22 lb.) child consuming 1 liter of water per day, a one- to ten-day exposure to 1 mg/L; a longer-term (7 years) exposure to 0.2 mg/L.

Chronic: Chromium has the potential to cause the following health effects from long-term exposures at levels above the MCL: damage to liver, kidney circulatory and nerve tissues; dermatitis.

Cancer: There is no evidence that chromium in drinking water has the potential to cause cancer from lifetime exposures in drinking water.

USAGE PATTERNS

Chromium and its compounds are used in metal alloys such as stainless steel; protective coatings on metal; magnetic tapes; and pigments for paints, cement, paper, rubber, composition floor covering and other materials. Other uses include: chemical intermediate for wood preservatives, organic chemical synthesis, photochemical processing and industrial water treatment. In medicine, chromium compounds are used in astringents and antiseptics. They also are used in cooling waters, and in the leather tanning industry, in catalytic manufacture, and in fungicides; as an algaecide against slime forming bacteria and yeasts in brewery processing water and brewery warmer water.

Chromic acid consumption patterns in 1988: wood preserving, 63%; metal finishing, 22%; other, including

TOXIC RELEASE INVENTORY - RELEASES TO WATER AND LAND: 1987 TO 1993

	Water	*Land*
TOTALS (in pounds)	2,876,055	196,880,624
Top Ten States*		
TX	102,079	64,301,920
NC	43,522	55,217,044
IN	85,570	15,955,895
OH	51,830	8,319,600
UT	1,750	5,817,015
AR	2,300	3,532,000
KY	255	2,491,519
PA	110,149	2,337,905
GA	679,721	1,404,698
ID	91,750	1,404,870
Major Industries*		
Indust. organics	3,272	120,707,814
Steelworks, Blast furn.	609,174	16,638,880
Electrometallurgy	33,269	10,796,928
Copper smelting, refining	1,750	5,817,015
Nonferrous smelting	2,300	3,532,000
Inorganic pigments	88,721	1,375,700
Pulp mills	985,800	224,198

* State/Industry totals only include facilities with releases greater than a certain amount - usually 1000 to 10,000 lbs.

water treatment, magnetic particles and catalysts, 7%; exports, 8%. Demand: 1987: 57,500 tons; 1988: 62,500 tons; 1992 (projected): 78,800 tons.

Sodium Bichromate consumption patterns in 1988: chromic acid, 54%; leather tanning, 9%; chromium oxide, 9%; pigments, 8%; wood preservation, 5%; other, including drilling muds, catalysts, water treatment, metal finishing, 5%; exports, 10%. Demand: 1987: 150,000 tons; 1988: 164,000 tons; 1992 (projected): 180,000 tons

RELEASE PATTERNS

Chromium occurs in nature mostly as chrome iron ore, or chromite. Though widely distributed in soils and plants, it is rare in natural waters. The two largest sources of chromium emission in the atmosphere are from the chemical manufacturing industry and combustion of natural gas, oil, and coal.

Other sources include wind transport from road dust, cement producing plants because cement contains chromium, the wearing down of asbestos brake linings from automobiles or similar sources of wind carried asbestos since asbestos contains chromium, incineration of municipal refuse and sewage sludge, exhaust emission from automotive catalytic converters, emissions from cooling towers that use chromium compounds as rust inhibitors, waste waters from electroplating, leather tanning, and textile industries when discharged into surface waters, and solid wastes from chemical manufacture.

From 1987 to 1993, according to the Toxics Release Inventory, chromium compound releases to land and water totalled nearly 200 million pounds, of which about 99 percent was to land. These releases were primarily from industrial organic chemical industries which use chromium as an intermediate. The largest releases occurred in Texas and North Carolina. The largest direct releases to water occurred in Georgia and Pennsylvania.

Background levels in water average 1 ug/L while municipal drinking water contain 0.1-35 ug/L. The higher values of chromium can be related to sources of anthropogenic pollution. In ocean water, the mean chromium concentration is lower than in river water; and its value is 0.3 ug/l, with a range of 0.2 to 50 ug/l.

A survey of 3834 tap waters reported the concentrations of chromium to range from 0.4 to 8.0 ug/l. The reported chromium concentrations in this study may be a little higher than the actual values due to inadequate flushing of tap water before collection of samples. This indicates that the concentration of chromium in household tap water may increase due to plumbing materials.

ENVIRONMENTAL FATE

Chromium is not likely to migrate to ground water. A field trial on the application of wastewater treatment sludge to soils found movement of heavy metals, including chromium, from the soil surface to a depth of 10 cm, but most of the metal (mean 87%) remained in the upper 5 cm of soil. Uptake by plants is generally low; it was found to be greater from ultrabasic soils by a factor of 5-40 than on calcareous or silica-based soils.

Chromium compounds are very persistent in water. Most of the chromium in surface waters may be present in particulate form as sediment. Some of the particulate chromium would remain as suspended matter and ultimately be deposited in sediments.

The exact chemical forms of chromium in surface waters are not well defined. Although most of the soluble chromium in surface waters may be present as Cr(VI), a small amount may be present as Cr(III) organic complexes. Hexavalent chromium is the major stable form of chromium in seawater; however, Cr(VI) may be reduced to Cr(III) by organic matter present in water, and may eventually deposit in sediments.

Though little data is available, there is a high potential for bioconcentration of chromium in aquatic organisms. Snails showed an accumulation factor of $1x10^{+6}$.

OTHER REGULATORY INFORMATION

MONITORING:

- FOR GROUND WATER SOURCES:
  - INITIAL FREQUENCY- 1 sample once every 3 years
  - REPEAT FREQUENCY- If no detections for 3 rounds, once every 9 years
- FOR SURFACE WATER SOURCES:
  - INITIAL FREQUENCY- 1 sample annually
  - REPEAT FREQUENCY- If no detections for 3 rounds, once every 9 years
- TRIGGERS - If detect at > 0.1 mg/L, sample quarterly.

ANALYSIS:

REFERENCE SOURCE	METHOD NUMBERS
EPA 600/4-79-020	218.2
NTIS PB 91-231498	3113B; 3120
Standard Methods	200.7

TREATMENT

BEST AVAILABLE TECHNOLOGIES

Coagulation/Filtration; Ion Exchange, Reverse Osmosis, Lime Softening (for CrIII only)

FOR ADDITIONAL INFORMATION:

♦ EPA can provide further regulatory and other general information:

- EPA Safe Drinking Water Hotline - 800/426-4791

♦ Other sources of toxicological and environmental fate data include:

- Toxic Substance Control Act Information Line - 202/554-1404
- Toxics Release Inventory, National Library of Medicine - 301/496-6531
- Agency for Toxic Substances and Disease Registry - 404/639-6000

United States Environmental Protection Agency
Office of Water 4601
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EPA

National Primary Drinking Water Regulations

Mercury

CHEMICAL/ PHYSICAL PROPERTIES

CAS NUMBER: 7439-97-6

COLOR/ FORM/ODOR: Silver-white, heavy, mobile, liquid metal. Solid mercury is tin-white. Odorless

M.P.: -38.87° C **B.P.:** 356.7° C

VAPOR PRESSURE: 2×10^{-3} mm Hg at 25° C

DENSITY/SPEC. GRAV.: 13.5 at 25° C

SOLUBILITY: 0.06 g/L of water at 25° C; Slightly soluble in water

SOIL SORPTION COEFFICIENT: N/A

ODOR/TASTE THRESHOLDS: N/A

BIOCONCENTRATION FACTOR: Bioconcentration factors of 63,000 for freshwater and 10,000 for salt water fishes. BCFs of 100,000 for invertebrates.

HENRY'S LAW COEFFICIENT: N/A; volatilization from water and soil is significant

SYNONYMS/ORES: Liquid silver, Quicksilver, Hydragyrum, Colloidial mercury. Important commercial ore is cinnabar, but also found in limestone, calcareous shales, sandstone, serpentine, chert andesite and others.

DRINKING WATER STANDARDS

MCLG: 0.002 mg/L

MCL: 0.002 mg/L

HAL(child): none

HEALTH EFFECTS SUMMARY

Acute: EPA has found mercury to potentially cause kidney damage from short-term exposures at levels above the MCL.

No Health Advisories have been established for short-term exposures.

Chronic: Mercury has the potential to cause kidney damage from long-term exposure at levels above the MCL.

Cancer: There is inadequate evidence to state whether or not mercury has the potential to cause cancer from lifetime exposures in drinking water.

USAGE PATTERNS

Nearly 8 million lbs. of mercury were produced in the U.S. in 1986.

Electrical products such as dry-cell batteries, fluorescent light bulbs, switches, and other control equipment account for 50% of mercury used. Mercury is also used in substantial quantities in electrolytic preparation of chlorine and caustic soda (chlor-alkali industry, mercury cell process; 25%), paint manufacture (12%), and dental preparations (3%). Lesser quantities are used in industrial catalyst manufacture (2%), pesticides manufacture (1%), general laboratory use (1%), and pharmaceuticals (0.1%).

RELEASE PATTERNS

A joint FAO/WHO expert committee on Food Additives in 1972 quotes the major source of mercury as the natural degassing of the earth's crust in the range of 25,000-150,000 ton of Hg/yr.

Twenty thousand tons of mercury are also released into the environment each year by human activities such as combustion of fossil fuels and other industrial release. Anthropogenic sources of airborne mercury (Hg) may arise from the operation of metal smelters or cement

TOXIC RELEASE INVENTORY - RELEASES TO WATER AND LAND: 1987 TO 1993

	Water	Land
TOTALS (in pounds)	6,971	60,877
Top Six States		
TN	164	29,161
LA	431	21,829
DE	117	3,860
OH	29	2,760
AL	1,462	1,001
WV	1,657	454
Major Industries		
Chemical, allied products	12,269	74,720
Electric lamps	0	2,750
Paper mills	2,500	0

manufacture. Water borne pollution may originate in sewage, metal refining operations, or most notably, from chloralkali plants. In general, industrial and domestic products, such as thermometers, batteries, and electrical switches which account for a significant loss of mercury to the environment, ultimately become solid waste in major urban areas.

From 1987 to 1993, according to EPA's Toxic Chemical Release Inventory, mercury releases to land and water totalled nearly 68,000 lbs., of which 90 percent was to land. These releases were primarily from chemical and allied industries. The largest releases occurred in Tennessee and Louisiana. The largest direct releases to water occurred in West Virginia and Alabama.

ENVIRONMENTAL FATE

Two characteristics, volatility and biotransformation, make mercury somewhat unique as an environmental toxicant. Its volatility accounts for atmospheric concentrations up to 4 times the level of contaminated soils in an area. Inorganic forms of mercury (Hg) can be converted to organic forms by microbial action in the biosphere.

In aquatic systems, mercury appears to bind to dissolved matter or fine particulates, while the transport of mercury bound to dust particles in the atmosphere or bed sediment particles in rivers and lakes is generally less substantial. The conversion, in aquatic environments, of inorganic mercury compounds to methyl mercury implies that recycling of mercury from sediment to water to air and back could be a rapid process. In a study of mercury elimination from wastewater, 47% of added mercury was removed in presence of a Pseudomonas strain. Uptake of mercury was severely inhibited by sodium chloride, sodium sulfate, and mono- and dibasic potassium phosphate.

In the atmosphere, 50% of the volatile form is mercury (Hg) vapor with sizeable portion of remainder being Hg(II) and methylmercury, 25 to 50% of Hg in water is organic. Hg in the environment is deposited and revolatilized many times, with a residence time in the atmosphere of at least a few days. In the volatile phase it can be transported hundreds of kilometers.

Bioconcentration factors of 63,000 for freshwater fish, 10,000 for salt water fish, 100,000 for marine invertebrates, and 1000 for freshwater and marine plants have been found. As the tissue concentration approaches steady-state, net accumulation rate is slowed either by a reduction in uptake rate, possibly due to inhibition of membrane transport, or by an increase in depuration rate, possibly because of a saturation of storage sites, or both. Acidification of a body of water might also increase mercury residues in fish even if no new input of mercury occurs, possibly because lower pH increases ventilation rate and membrane permeability, accelerates the rates of methylation and uptake, affects partitioning between sediment and water, or reduces growth or reproduction of fish.

OTHER REGULATORY INFORMATION

MONITORING:

- FOR GROUND WATER SOURCES:
  - INITIAL FREQUENCY- 1 sample once every 3 years
  - REPEAT FREQUENCY- If no detections for 3 rounds, once every 9 years
- FOR SURFACE WATER SOURCES:
  - INITIAL FREQUENCY- 1 sample annually
  - REPEAT FREQUENCY- If no detections for 3 rounds, once every 9 years
- TRIGGERS - If detect at > 0.002 mg/L, sample quarterly.

ANALYSIS:

REFERENCE SOURCE	METHOD NUMBERS
EPA 600/4-79-020	245.1; 245.2
Standard Methods	303F

TREATMENT

BEST AVAILABLE TECHNOLOGIES

Coagulation/Filtration*; Granular Activated Carbon; Lime softening*; Reverse osmosis*

* These treatments are recommended only if influent Hg concentrations do not exceed 10 ug/L.

FOR ADDITIONAL INFORMATION:

♦ EPA can provide further regulatory and other general information:

- EPA Safe Drinking Water Hotline - 800/426-4791

♦ Other sources of toxicological and environmental fate data include:

- Toxic Substance Control Act Information Line - 202/554-1404
- Toxics Release Inventory, National Library of Medicine - 301/496-6531
- Agency for Toxic Substances and Disease Registry - 404/639-6000
- National Pesticide Hotline - 800/858-7378

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National Primary Drinking Water Regulations

Nitrates and Nitrites

CHEMICAL/ PHYSICAL PROPERTIES

CAS Number: Nitrate ion: 14797-55-8; Nitrite ion: 14797-65-0

COLOR/ FORM/ODOR: Domestic fertilizer grade ammonium or potassium nitrates are in prilled (beaded) or crystalline forms, usually coated with an anti-caking agent and adsorbed fuel oil.

SOLUBILITIES: Nitrates and nitrites are highly soluble in water

SOIL SORPTION COEFFICIENT: N/A

BIOCONCENTRATION FACTOR: N/A

TRADE NAMES/SYNONYMS:

Potassium salt: Potnit, Hitec, Niter, Nitrate of potash, Saltpeter.

Ammonium salt: German or Norway saltpeter, Varioform I, Merco or Herco prills, Nitram.

DRINKING WATER STANDARDS (IN MG/L)

	MCLG	MCL	HAL(10 day)
Nitrate:	10	10	10
Nitrite:	1	1	1
Total (Nitrate+Nitrite)	10	10	10

EALTH EFFECTS SUMMARY

Acute: Excessive levels of nitrate in drinking water have caused serious illness and sometimes death. The serious illness in infants is due to the conversion of nitrate to nitrite by the body, which can interfere with the oxygen-carrying capacity of the child's blood. This can be an acute condition in which health deteriorates rapidly over a period of days. Symptoms include shortness of breath and blueness of the skin.

Drinking water levels which are considered "safe" for short-term exposures: For a 10-kg (22 lb.) child consuming 1 liter of water per day, a ten-day exposure to 10 mg/L total nitrate/nitrite.

Chronic: Effects of chronic exposure to high levels of nitrate/nitrite include diuresis, increased starchy deposits and hemorrhaging of the spleen.

Cancer: There is inadequate evidence to state whether or not nitrates or nitrites have the potential to cause cancer from lifetime exposures in drinking water.

USAGE PATTERNS

Most nitrogenous materials in natural waters tend to be converted to nitrate, so all sources of combined itrogen, particularly organic nitrogen and ammonia,

TOXIC RELEASE INVENTORY - RELEASES TO WATER AND LAND: 1987 TO 1993

	Water	Land
TOTALS (in pounds)	59,014,378	53,134,805
Top Fifteen States*		
GA	12,114,253	12,028,585
CA	0	21,840,999
AL	3,463,097	6,014,674
LA	8,778,237	2,250
MO	6,985,890	206,181
MS	6,952,387	0
KS	5,140,000	877,095
VA	5,091,764	0
NV	0	4,977,482
FL	1,056,560	1,835,736
AR	1,206,610	1,058,294
MD	1,802,219	138,819
IA	1,500,340	132,042
OK	1,436,348	14,199
UT	0	1,045,400
Major Industries*		
Nitrogenous fertilizer	41,584,611	8,607,376
Misc. Ind. inorganics	4,113,312	29,676,919
Misc. Metal ores	0	5,764,976
Misc. Ind. organics	5,091,764	0
Fertilizer mixing	480,000	4,554,916
Explosives	850,921	1,297,590
Paper mills	1,727,061	0
Pulp mills	1,321,500	3,350
Canned foods	0	1,056,794
Phosphate fertilizers	1,000,000	0

* State/Industry totals only include facilities with releases greater than 10,000 lbs.

should be considered as potential nitrate sources. Primary sources of organic nitrates include human sewage and livestock manure, especially from feedlots.

The primary inorganic nitrates which may contaminate drinking water are potassium nitrate and ammonium nitrate. Potassium nitrates are used mainly as fertilizers (85%), with the remainder in heat transfer salts, glass and ceramics, and in matches and fireworks. Ammonium nitrates are used as fertilizers (84%) and in explosives and blasting agents (16%).

RELEASE PATTERNS

The major environmental releases of inorganic sources of nitrates are due to the use of fertilizers.

According to the Toxics Release Inventory, releases to water and land totalled over 112 million pounds from 1991 through 1993. The largest releases of inorganic nitrates occurred in Georgia and California.

ENVIRONMENTAL FATE

Due to its high solubility and weak retention by soil, nitrates are very mobile in soil, moving at approximately the same rate as water, and has a high potential to migrate to ground water. Because it does not volatilize, nitrate/nitrite is likely to remain in water until consumed by plants or other organisms. Ammonium nitrate will be taken up by bacteria. Nitrate is more persistent in water than the ammonium ion. Nitrate degradation is fastest in anaerobic conditions.

OTHER REGULATORY INFORMATION

MONITORING:

FOR GROUND WATER SOURCES:

INITIAL FREQUENCY- Nitrate: 1 sample annually
Nitrite: 1 sample during first 3-year compliance period

REPEAT FREQUENCY- Nitrate: 1 sample annually
Nitrite: determined by State

FOR SURFACE WATER SOURCES:

INITIAL FREQUENCY- Nitrate: 1 sample each quarter
Nitrite: 1 sample during first 3-year compliance period

REPEAT FREQUENCY- Nitrate: 1 sample annually
Nitrite: determined by State

TRIGGERS - If detect at > 5 mg/L nitrate, sample quarterly.
If detect at > 0.5 mg/L nitrite, sample quarterly.
If detect total nitrate + nitrite > 5 mg/L, sample quarterly

ANALYSIS:

REFERENCE SOURCE	METHOD NUMBERS
EPA 600/4-79-020	353.1; 353.2; 353.3; 300.0; 354.1
Standard Methods	418C; 418F
ASTM	D3867-85A; D3867-85B

TREATMENT

BEST AVAILABLE TECHNOLOGIES

Ion exchange; Reverse osmosis; Electrodialysis (nitrate only)

FOR ADDITIONAL INFORMATION:

♦ EPA can provide further regulatory and other general information:
- EPA Safe Drinking Water Hotline - 800/426-4791

♦ Other sources of toxicological and environmental fate data include:
- Toxic Substance Control Act Information Line - 202/554-1404
- Toxics Release Inventory, National Library of Medicine - 301/496-6531
- Agency for Toxic Substances and Disease Registry - 404/639-6000

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National Primary Drinking Water Regulations

Selenium

CHEMICAL/ PHYSICAL PROPERTIES

CAS NUMBER: 7782-49-2

COLOR/ FORM/ODOR: Selenium is a metal which exists in nature only in the combined form.

SOIL SORPTION COEFFICIENT: N/A

BIOCONCENTRATION FACTOR: BCF of 1000 in humans; 50,000 in marine fish

SOLUBILITIES:

dioxide-	384 g/L at 14 deg C
hydrogen-	3.8 L/L at 4 deg C (hydrogen selenide)
sodium-	850 g/L at 20 deg C
sulfide-	insoluble

COMMON ORES: Usually found in the sulfide ores of the heavy metals, such as pyrite, clausthalite, naumannite, tiemannite. Also found in coal.

DRINKING WATER STANDARDS

MCLG:	0.05 mg/l
MCL:	0.05 mg/l
HAL(child):	none

[illegible]EALTH EFFECTS SUMMARY

Acute: Selenium is an essential nutrient at low levels. However, EPA has found it to potentially cause the following health effects from acute exposures at levels above the MCL: hair and fingernail changes; damage to the peripheral nervous system; fatigue and irritability.

No Health Advisories have been established for short-term exposures.

Chronic: Selenium has the potential to cause the following health effects from long-term exposures at levels above the MCL: hair and fingernail loss; damage to kidney and liver tissue; and the nervous and circulatory systems.

Cancer: There is no evidence that selenium has the potential to cause cancer from lifetime exposures in drinking water.

USAGE PATTERNS

Selenium is used extensively in the manufacture and production of glass, pigments, rubber, metal alloys, textiles, petroleum, medical therapeutic agents, and photographic emulsions. Selenium dioxide is the most widely used selenium compound in industry. It is used as [illegible]n oxidizing agent in drug and other chemical manufac[illegible]re; a catalyst in organic syntheses; an antioxidant in lubricating oils.

Production in 1985 was reported to be 429,515 pounds, with demand for its various uses as follows: electronic and photocopier components, 35%; Glass manufacturing, 30%; Chemical and pigments, 25%; and Other, 10%.

RELEASE PATTERNS

There are no true deposits of selenium anywhere and it cannot economically be recovered from the earth directly. It usually occurs in the sulfide ores of the heavy metals; this includes pyrite, clausthalite, naumannite, tienammite and in selenosulfur. Soils in the neighborhood of volcanoes tend to have enriched amounts of

TOXIC RELEASE INVENTORY - RELEASES TO WATER AND LAND: 1987 TO 1993

	Water	Land
TOTALS (in pounds)	13,556	1,010,686
Top Five States *		
UT	1,578	696,515
AZ	0	260,632
WI	0	45,000
IN	5,300	0
TX	359	4,920
*Major Industries**		
Copper smelting, refining	1,500	962,067
Metal coatings	0	45,000
Petroleum refining	8,949	977

* Land totals only include facilities with releases greater than 1000 lbs.

selenium. Selenium is the most strongly enriched element in coal, being present as an organoselenium compound, a chelated species, or as an adsorbed element.

Selenium compounds are released to the air during the combustion of coal and petroleum fuels, and during the smelting and refining of other metals.

From 1987 to 1993, according to the Toxics Release Inventory selenium releases to land and water totalled over 1 million lbs., of which about 99 percent was to land. These releases were primarily from copper smelting industries. The largest releases occurred in Utah. The largest direct releases to water occurred in Indiana.

Selenium concentration in fresh water is usually around 0.02 ppm. The selenium content of surface water is greatly influenced by pH, being high in acidic (pH < 3.0) and in alkaline waters (pH > 7.5). Traces of selenium ranging from 0.0000-0.01 ppm are commonly found in community drinking water.

Environmental Fate

The toxicity of selenium depends on whether it is in the biologically active oxidized form. In alkaline soils and oxidizing conditions, selenium may be oxidized sufficiently to maintain the availability of its biologically active form, and cause plant uptake of the metal to be increased.

In acidic or neutral soils, it tends to remain relatively insoluble and the amount of biologically available selenium should steadily decrease. Selenium volatilizes from soils when converted to volatile selenium compounds (such as dimethyl selenide, dimethyl diselenide, and others) by microorganisms.

It is known that selenium accumulates in living tissues. For example, the selenium content of human blood is about 0.2 ppm. This value is about 1000 times greater than the selenium found in surface waters. It is clear that the human body does accumulate or concentrate selenium with respect to the environmental levels of selenium. Selenium has been found in marine fish meal at levels of about 2 ppm. This amount is around 50,000 times greater than the selenium found in seawater.

Selenium dioxide is the primary source of problems from industrial exposures since the dioxide forms selenious acid with water or sweat, and the acid is an irritant. Selenium compounds released during coal or petroleum combustion may be a significant source of exposure.

Other Regulatory Information

Monitoring:

- **For Ground Water Sources:**
  - **Initial Frequency-** 1 sample once every 3 years
  - **Repeat Frequency-** If no detections for 3 rounds, once every 9 years
- **For Surface Water Sources:**
  - **Initial Frequency-** 1 sample annually
  - **Repeat Frequency-** If no detections for 3 rounds, once every 9 years
- **Triggers** - If detect at > 0.05 mg/L, sample quarterly.

Analysis:

Reference Source	Method Numbers
EPA 600/4-79-020	270.2
ASTM Standards 1991	D3859-84A; D3859-88
Standard Methods (17th ed.)	3113B; 3114B

Treatment

Best Available Technologies

Activated Alumina, Coagulation/Filtration (SeVI only), Lime Softening, Reverse Osmosis, Electrodialysis

For Additional Information:

♦ EPA can provide further regulatory and other general information:
- EPA Safe Drinking Water Hotline - 800/426-4791

♦ Other sources of toxicological and environmental fate data include:
- Toxic Substance Control Act Information Line - 202/554-1404
- Toxics Release Inventory, National Library of Medicine - 301/496-6531
- Agency for Toxic Substances and Disease Registry - 404/639-6000

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Lead

CHEMICAL/ PHYSICAL PROPERTIES

CAS NUMBER: 7439-92-1

COLOR/ FORM/ODOR: Bluish-white, silvery, gray metal, lustrous when freshly cut.

SOIL SORPTION COEFFICIENT: N/A; Low mobility in most soils, lowest at neutral pH and high organic matter.

COMMON ORES:
sulfide-Galena; oxide-Lanarkite; carbonate-Cerrusite; sulfate-Anglesite

BIOCONCENTRATION FACTOR: Log BCFs for fish, 1.65; shellfish, 3.4

SOLUBILITIES:

acetate-	443 g/L at 20 deg C
arsenate-	insoluble in cold water
carbonate-	0.0011 g/L at 20 deg C
chloride-	10 g/L cold water
chromate-	0.2 mg/L
nitrate-	376.5 g/L at 0 deg C
oxide-	0.05 g/L at 20 deg C
dioxide-	insoluble
phosphate-	insoluble
sulfate-	0.4 g/L
sulfide-	insoluble
tetraethyl-	0.29 mg/L at 25 deg C
thiocyanate-	0.5 g/L at 20 deg C
thiosulfate-	0.3 g/L cold water

DRINKING WATER STANDARDS

MCLG:	zero
Action Level:	> 0.015 mg/L in more than 10 percent of tap water samples
HAL(child):	none

HEALTH EFFECTS SUMMARY

Acute: Lead can cause a variety of adverse health effects in humans. At relatively low levels of exposure, these effects may include interference with red blood cell chemistry, delays in normal physical and mental development in babies and young children, slight deficits in the attention span, hearing, and learning abilities of children, and slight increases in the blood pressure of some adults. It appears that some of these effects, particularly changes in the levels of certain blood enzymes and in aspects of children's neurobehavioral development, may occur at blood lead levels so low as to be essentially without a threshold.

Chronic: Chronic exposure to lead has been linked to cerebrovascular and kidney disease in humans.

Cancer: Lead has the potential to cause cancer from a lifetime exposure at levels above the action level.

USAGE PATTERNS

Lead is the fifth most important metal in the USA economy in terms of consumption. Of this approximately 85% of the primary lead is produced domestically and 40-50% is recovered and recycled. Eighty eight percent of the lead mined in the US comes from seven mines in the New Lead Belt in southeastern Missouri; the rest coming from eight mines in Colorado, Idaho, and Utah. Three of the six USA lead smelters are from this region, the others are located in Idaho, Montana, and Texas.

RELEASE PATTERNS

Lead occurs in drinking water from two sources: (1) Lead in raw water supplies, i.e., source water or distributed water, and (2) corrosion of plumbing materials in the water distribution system (corrosion by-products). Most lead contamination is from corrosion by-products.

Occurrence in Source Water and Distributed Water. Based on a variety of water quality surveys, EPA now estimates that approximately 600 groundwater systems and about 215 surface suppliers may have water leaving the treatment plant with lead levels greater than 0.005 mg/L. These two sources together indicate that less than 1 percent of the public water systems in the United States have water entering the distribution system with lead levels greater than 0.005 mg/L. These systems serve less than 3 percent of people that receive their drinking water from public water systems.

From 1987 to 1993, according to the Toxics Release Inventory lead compound releases to land and water totalled nearly 144 million lbs., almost all of which was to land. These releases were primarily from lead and copper smelting industries. The largest releases occurred in Missouri, Arizona and Montana. The largest direct releases to water occurred in Ohio.

Occurrence as a Corrosion By Product. Lead in drinking water results primarily from corrosion of materials located

Toxics Release Inventory - Water and Land Releases, 1987-93

	Water	Land
TOTALS (in pounds)	970,827	143,058,771
*Top Twelve States **		
MO	4,408	40,656,278
AZ	771	23,240,625
MT	0	20,822,517
UT	4,600	11,881,000
TX	1,988	11,515,211
OH	127,990	5,196,522
IN	62,894	4,851,940
TN	7,140	2,095,489
IL	26,601	1,930,000
WI	1,310	1,350,960
MN	0	1,313,895
NM	0	1,060,880
*Major Industries**		
Lead smelting/refining	31,423	68,996,819
Copper smelting	5,371	34,942,505
Steelworks/blast furn.	379,049	18,149,606
Storage batteries	0	1,867,292
China plumbing fixtures	1,310	1,350,960
Iron foundries	10,021	1,274,777
Copper mining	0	1,240,000

* State/Industry totals only include facilities with releases greater than 100,000 lbs.

throughout the distribution system containing lead and copper and from lead and copper plumbing materials used to plumb public- and privately-owned structures connected to the distribution system. The amount of lead in drinking water attributable to corrosion by-products depends on a number of factors, including the amount and age of lead and copper bearing materials susceptible to corrosion, how long the water is in contact with the lead containing surfaces, and how corrosive the water in the system is toward these materials.

The potential sources of lead corrosion by-products found in drinking water can include: Water service mains (rarely), lead goosenecks or pigtails, lead service lines and interior household pipes, lead solders and fluxes used to connect copper pipes, alloys containing lead, including some faucets made of brass or bronze.

Most public water systems serve at least some buildings with lead solder and/or lead service lines. EPA estimates that there are about 10 million lead service lines/connections. About 20 percent of all public water systems have some lead service lines/connections within their distribution system.

The amount of lead in drinking water depends heavily on the corrosivity of the water. All water is corrosive to metal plumbing materials to some degree, even water termed noncorrosive or water treated to make it less corrosive. The corrosivity of water to lead is influenced by water quality parameters such as pH, total alkalinity, dissolved inorganic carbonate, calcium, and hardness. Galvanic corrosion of lead into water also occurs with lead-soldered copper pipes, due to differences in the electrochemical potential of the two metals. Grounding of household electrical systems to plumbing may also exacerbate galvanic corrosion.

Environmental Fate

Lead may enter the environment during its mining, ore processing, smelting, refining use, recycling or disposal. The initial means of entry is via the atmosphere. Lead may also enter the atmosphere from the weathering of soil and volcanos, but these sources are minor compared with anthropogenic ones.

Lead will be retained in the upper 2-5 cm of soil, especially soils with at least 5% organic matter or a pH 5 or above. Leaching is not important under normal conditions. It is expected to slowly undergo speciation to the more insoluble sulfate, sulfide, oxide, and phosphate salts.

Lead enters water from atmospheric fallout, runoff or wastewater; little is transferred from natural ores. Metallic lead is attacked by pure water in the presence of oxygen, but if the water contains carbonates and silicates, protective films are formed preventing further attack. That which dissolves tends to form ligands. Lead is effectively removed from the water column to the sediment by adsorption to organic matter and clay minerals, precipitation as insoluble salt, and reaction with hydrous iron and manganese oxide. Under most circumstances, adsorption predominates.

Lake sediment microorganisms are able to directly methylate certain inorganic lead compounds. Under appropriate conditions, dissolution due to anaerobic microbial action may be significant in subsurface environments. The mean percentage removal of lead during the activated sludge process was 82% and was almost entirely due to the removal of the insoluble fraction by adsorption onto the sludge floc and to a much lesser extent, precipitation.

The most stable form of lead in natural water is a function of the ions present, the pH, and the redox potential. In oxidizing systems, the least soluble common forms are probably the carbonate, hydroxide, and hydroxycarbonate. In reduced systems where sulfur is present, PbS is the stable solid. The solubility of Pb is 10 ppb above pH 8, while near pH 6.5 the solubility can approach or exceed 100 ppb. Pb(0) and Pb(+2) can be oxidatively methylated by naturally occurring compounds such as methyl iodide and glycine betaine. This can result in the dissolution of lead already bound to sediment or particulate matter.

Lead does not appear to bioconcentrate significantly in fish but does in some shellfish such as mussels. Evidence suggests that lead uptake in fish is localized in the mucous on the epidermis, the dermis, and scales so that the availability in edible portions do not pose a human health danger.

Other Regulatory Information:

Monitoring:	*For Lead*	*For Water Quality Parameters*	
	At Home Taps	**Within the Distribution System**	**At Entry to the Distribution System**
Monitoring Period			
Initial	Every 6 months	Every 6 months	Every 6 months
After corrosion control installation	Every 6 months	Every 6 months	Every 2 weeks
Reduced monitoring			
- Conditional	Once a year	Every 6 months	Every 2 weeks
- Final	Every 3 years	Every 3 years	Every 2 weeks

Analysis

Reference Source	**Method Number**
EPA 800/4-83-043	239.2; 200.8; 200.9

Treatment: Best Available Technologies

Source water: Ion exchange; lime softening; reverse osmosis; coagulation/filtration

Corrosion Control: pH and alkalinity adjustment; calcium adjustment; silica- or phosphate-based corrosion inhibition

For Additional Information:

- EPA can provide further regulatory and other general information:
  - EPA Safe Drinking Water Hotline - 800/426-4791
- Other sources of toxicological and environmental fate data include:
  - Toxic Substance Control Act Information Line - 202/554-1404
  - Toxics Release Inventory, National Library of Medicine - 301/496-6531
  - Agency for Toxic Substances and Disease Registry - 404/639-6000

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National Primary Drinking Water Regulations

Copper

CHEMICAL/ PHYSICAL PROPERTIES

CAS NUMBER: 7440-50-8 (metal)

COLOR/ FORM/ODOR: Reddish metal which may occur in water as copper salts, the most common of which are the chloride, nitrate and sulfate salts.

SOIL SORPTION COEFFICIENT: N/A

SOLUBILITIES (G/L WATER AT 20 DEG C): Chloride, 770; Nitrate, 1250; Sulfate, 207.

BIOCONCENTRATION FACTOR: N/A

COMMON ORES: Found as sulfides, arsenites, chlorides, and carbonates in the following ores: Chalcopyrite, Chalcocite, Bomite, Tetrahedrite, Enargite, Antlerite

DRINKING WATER STANDARDS

MCLG:	1.3 mg/L
ACTION LEVEL:	> 1.3 mg/L in 10 percent or more of tap water samples
HAL(child):	none

HEALTH EFFECTS SUMMARY

Acute and Chronic: Copper is an essential nutrient, but at high doses it has been shown to cause stomach and intestinal distress, liver and kidney damage, and anemia. Persons with Wilson's disease may be at a higher risk of health effects due to copper than the general public.

Cancer: There is inadequate evidence to state whether or not copper has the potential to cause cancer from a lifetime exposure in drinking water.

USAGE PATTERNS

Copper occurs in drinking water primarily due to its use in plumbing materials.

Occurrence in Source Water and Distributed Water. Copper levels above the MCLG are rarely found in raw drinking water supplies or in distributed water. EPA estimates that only 66 water systems have copper levels in source water greater than the MCLG.

Occurrence as a Corrosion By- Product. The primary source of copper in drinking water is corrosion of copper pipes, which are widely used throughout the United States for interior plumbing of residences and other buildings. In some cases, copper is a component of additives to drinking water used by systems to control the growth of algae.

RELEASE PATTERNS

Although copper rarely occurs in source water, the following natural and artificial sources have been identified. Copper is widely distributed in nature in the elemental state, in sulfides, arsenites, chlorides, and carbonates. The element is only superficially oxidized in air,

TOXIC RELEASE INVENTORY - RELEASES TO WATER AND LAND: 1987 TO 1993

	Water	Land
TOTALS (in pounds)	1,538,148	442,082,245
*Top Ten States **		
UT	55,350	153,501,500
NM	0	130,682,387
AZ	2,636	104,619,532
MI	19,763	11,172,897
NY	66,057	10,017,766
MT	0	8,696,153
TN	301,417	1,208,804
MO	250	1,486,000
AL	41,213	513,536
MD	78,601	270,945
*Major Industries**		
Primary copper smelting	7,591	201,214,264
Other nonferrous smelt.	4,414	11,317,048
Plastic materials	44,422	9,637,850
Blast fumaces, steel	156,982	3,229,752
Poultry slaughtering	0	1,249,750
Copper rolling, drawing	17,253	941,075
Ind. organic chems	28,936	827,356
Prepared feeds, misc.	1,038	760,094
Ind. inorganic chems	220,503	527,458

* State/industry totals only include facilities with releases greater than a certain amount - usually 1000 to 10,000 lbs.

sometimes giving a green coating of hydroxy carbonate and hydroxy sulfate. The concentration of copper in the continental crust, generally estimated at 50 ppm, tends to be highest in the ferromagnesium minerals, such as the basalts pyropene and biotite, where it averages 140 ppm. Sandstones contain 10-40 ppm, shales 30-150 ppm, and marine black shales 20-300 ppm. Coal is relatively low in copper.

In the sedimentary cycle copper is concentrated in the clay mineral fractions with a slight enrichment in those clays rich in organic carbon.

Smelting operations and municipal incineration may also produce copper. Water and pasture have been found to be contaminated with copper in the vicinity of copper mines or smelting works. The principal source of elevated copper levels in air is copper dust generated by copper processing operations.

From 1987 to 1993, according to the Toxics Release Inventory copper compound releases to land and water totalled nearly 450 million lbs., of which nearly all was to land. These releases were primarily from copper smelting industries. The largest releases occurred in Utah. The largest direct releases to water occurred in Tennessee.

ENVIRONMENTAL FATE

As with lead, all water is corrosive toward copper to some degree, even water termed noncorrosive or water treated to make it less corrosive. Corrosivity toward copper depends primarily on the pH of the water, with very low pHs associated with the highest levels of copper corrosion by-products. Many of the other factors that affect the corrosivity of water toward lead can also be expected to affect the corrosion of copper.

OTHER REGULATORY INFORMATION

MONITORING:	*FOR COPPER*	*FOR WATER QUALITY PARAMETERS*	
SAMPLING SITE:	**AT HOME TAPS**	**WITHIN THE DISTRIBUTION SYSTEM**	**AT ENTRY TO THE DISTRIBUTION SYSTEM**
MONITORING PERIOD:			
Initial	Every 6 months	Every 6 months	Every 6 months
After corrosion control installation	Every 6 months	Every 6 months	Every 2 weeks
Reduced monitoring			
- Conditional	Once a year	Every 6 months	Every 2 weeks
- Final	Every 3 years	Every 3 years	Every 2 weeks

ANALYSIS FOR COPPER

REFERENCE SOURCE	**METHOD NUMBER**
EPA 800/4-83-043	220.2; 220.1
Standard Methods	3111-B; 3120

TREATMENT: BEST AVAILABLE TECHNOLOGIES

Source water: Ion exchange; lime softening; reverse osmosis; coagulation/filtration

Corrosion Control: pH and alkalinity adjustment; calcium adjustment; silica- or phosphate-based corrosion inhibition

FOR ADDITIONAL INFORMATION:

♦ EPA can provide further regulatory and other general information:

- EPA Safe Drinking Water Hotline - 800/426-4791

♦ Other sources of toxicological and environmental fate data include:

- Toxic Substance Control Act Information Line - 202/554-1404
- Toxics Release Inventory, National Library of Medicine - 301/496-6531
- Agency for Toxic Substances and Disease Registry - 404/639-6000

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National Primary Drinking Water Regulations

Antimony

Chemical/ Physical Properties

CAS Number: 1440-36-0 (metal)

Color/ Form/Odor: Antimony is a metal which occurs in nature only in the combined state

Soil sorption coefficient: N/A

Bioconcentration Factor: BCF up to 300; may accumulate in some aquatic organisms

Solubilities:

stibine-	slightly soluble
trifluoride-	4.4 kg/L at 20 deg C
trioxide-	slightly soluble
trisulfide-	1.8 mg/L at 18 deg C

Common Ores: trioxide- Valentinite; sulfide- Stibnite; Other ores/natural sources: cervantite, livingstonite, jamisonite, kermesite, petroleum

Drinking Water Standards

Mclg:	0.006 mg/l
Mcl:	0.006 mg/l
Hal(child):	1- to 10-day: 0.01 mg/L
	Longer-term: 0.01 mg/L

Health Effects Summary

Acute: EPA has found antimony to potentially cause the following health effects from acute exposures at levels above the MCL: nausea, vomiting and diarrhea.

Short-term exposures in drinking water considered "safe" for a 10-kg (22 lb.) child consuming one liter of water per day: a long-term (upto 7 years) exposure to 0.01 mg/L.

Chronic: Antimony has the potential to cause the following health effects from long-term exposures at levels above the MCL: decreased longevity, altered blood levels of glucose and cholesterol.

Cancer: There is inadequate evidence to state whether or not antimony has the potential to cause cancer from lifetime exposures in drinking water.

Usage Patterns

In 1984, 64.5 million lbs. antimony ore was mined and refined. Production of the most commonly used antimony compound, the trioxide, increased during the 1980s to about 31 million lbs, reported in 1985.

In 1985, it was estimated that industries consumed antimony trioxide as follows: Flame retardant, 76%; catalyst, 6%; pigments, 5%; glass, 8%; miscellaneous, 5%. Primary antimony was used as follows: Flame retardant, 60%; transportation (including batteries), 10%; ceramics/glass, 10%; other uses, 10%.

Toxic Release Inventory - Releases to Water and Land: 1987 to 1993

	Water	Land
TOTALS (In pounds)	330,064	12,003,373
Top Ten States *		
AZ	505	7,074,128
MT	0	2,338,697
TX	24,817	840,392
LA	55,414	344,762
WI	1,445	392,000
MO	784	188,266
WA	63,220	99,915
ID	2,600	140,250
TN	687	108,325
AL	27,536	69,503
Major Industries*		
Copper smelting, refining	505	7,074,128
Other nonferrous smelt.	17,015	2,383,947
Sec. nonferrous smelt.	1,459	803,398
Misc Indust. Organics	18,424	581,465
Porcelain plumb. fixtures	1,445	392,000
Petroleum refining	111,527	202,251
Misc Inorganic chems.	4,962	140,250
Plastics, resins	20	60,372
Storage batteries	0	45,952
Synthetic fibers	26,803	12,535

* Water/Land totals only include facilities with releases greater than a certain amount - usually 1000 to 10,000 lbs.

RELEASE PATTERNS

The most common antimony ores are the sulfide, stibnite, and the trioxide, valentinite. Other ores include cervantite, livingstonite, jamisonite, and kermesite. Antimony is also a common component of coal and petroleum.

Industrial dust and exhaust gases of cars and oil fuels are the main sources of antimony in urban air. Substantial amounts of antimony trioxide are released to the atmosphere during processing of antimony materials including smelting of ores, molding and incineration of products, as well as the combustion of fossil fuels which are utilize the high temperatures needed to volatilize antimony trioxide.

From 1987 to 1993, according to the Toxics Release Inventory antimony and antimony compound releases to land and water totalled over 12 million lbs., of which nearly all was to land. These releases were primarily from copper and other nonferrous smelting and refining industries. The largest releases occurred in Arizona and Montana. The greatest releases to water occurred in Washington and Louisiana.

ENVIRONMENTAL FATE

Little information is available on the transformations and transport of antimony in various media. The mobility of antimony in soils is not clearly understood. The strength of its adscrption to soil and sediments depends upon a variety of factors such as pH, organic matter content, as well as the oxidation state of the particular salt. Some studies indicate that antimony is highly mobile, while others conclude that it strongly adsorbs to soil. In water, it usually adheres to sediments.

There is no evidence of bioconcentration of most antimony compounds, though one report states that the tribromide can be concentrated by certain forms of marine life to over 300 times its concentration in water.

OTHER REGULATORY INFORMATION

MONITORING:

- FOR GROUND WATER SOURCES:
  - INITIAL FREQUENCY- 1 sample once every 3 years
  - REPEAT FREQUENCY- If no detections for 3 rounds, once every 9 years
- FOR SURFACE WATER SOURCES:
  - INITIAL FREQUENCY- 1 sample annually
  - REPEAT FREQUENCY- If no detections for 3 rounds, once every 9 years
- TRIGGERS - If detect at > 0.006 mg/L, sample quarterly.

ANALYSIS

REFERENCE SOURCE	METHOD NUMBER
EPA 600/4-79-020	204.2
NTIS PB 91-231498	200.9; 200.8
Standard Methods	3113
ASTM	D3697-87

TREATMENT

BEST AVAILABLE TECHNOLOGIES

Ion Exchange, Lime Softening, Reverse Osmosis, Electrodialysis

FOR ADDITIONAL INFORMATION:

♦ EPA can provide further regulatory and other general information:

- EPA Safe Drinking Water Hotline - 800/426-4791

♦ Other sources of toxicological and environmental fate data include:

- Toxic Substance Control Act Information Line - 202/554-1404
- Toxics Release Inventory, National Library of Medicine - 301/496-6531
- Agency for Toxic Substances and Disease Registry - 404/639-6000

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Beryllium

CHEMICAL/ PHYSICAL PROPERTIES

CAS NUMBER: 7440-41-7

COLOR/ FORM/ODOR: Beryllium is a grayish metal which exists in nature only in combined forms, and in some precious stones such as emeralds, aquamarine.

SOIL SORPTION COEFFICIENT: N/A

BIOCONCENTRATION FACTOR: Nitrate BCF = 100 under constant exposure; not expected to bioaccumulate.

SOLUBILITIES:

chloride	very soluble
fluoride	very soluble
hydroxide	slightly sol. in dil. alkali
oxide	insoluble
phosphate	poorly soluble
sulfate-	insol. in cold water

COMMON ORES: Major commercial ore is bertrandite; oxide-bromellite; others: phenacite, pegmatite bodies.

DRINKING WATER STANDARDS

MCLG:	0.004 mg/l
MCL:	0.004 mg/l
HAL(child):	1- to 10-day: 30 mg/L
	Longer-term: 4 mg/L

HEALTH EFFECTS SUMMARY

Acute: EPA has found beryllium to potentially cause the following health effects from acute exposures at levels above the MCL: inhalation may cause acute chemical pneumonitis; less toxic via oral exposure.

Short-term exposures in drinking water considered "safe" for a 10-kg (22 lb.) child consuming one liter of water per day: up to a ten-day exposure to 30 mg/L; a longer-term exposure (upto 7 years) to 4 mg/L.

Chronic: Beryllium has the potential to cause the following health effects from long-term exposures at levels above the MCL: damage to bones and lungs.

Cancer: There is limited evidence that beryllium may cause cancer from lifetime exposures at levels above the MCL.

USAGE PATTERNS

Production of beryllium metal increased during the 1980s: from almost 300,000 lbs. in 1982 to 490,000 lbs in 1986. In 1986, it was estimated that the greatest use of beryllium is as an alloy and metal in nuclear reactors and aerospace applications, which consumed 40% of all production in 1986. Consumption for other uses: as an alloy and oxide in electrical equipment, 35%; as an alloy and oxide in electronic components, 17%; and as compounds and metal in other applications, 8%.

Beryllium metal is used as a hardener in alloys; in space vehicles, navigation and optical equipment, and missile fuel. The chloride is used as a catalyst and intermediate in chemical manufacture. The oxide is used in glass/ceramics; as a component of nuclear fuels and moderators, electric heat sinks; electrical insulators; microwave oven components; gyroscopes; military vehicle armor; rocket nozzles; crucibles; thermocouple tubing; laser structural components.

TOXIC RELEASE INVENTORY - RELEASES TO WATER AND LAND: 1987 TO 1993

	Water	Land
TOTALS (in pounds)	1,314	341,721
*Top Five States**		
PA	653	174,250
OH	490	166,292
MI	5	1,000
TX	0	174
MN	142	0
*Major Industries**		
Copper rolling, drawing	405	180,502
Nonferrous metal smelting	481	151,790
Nonferrous rolling, drawing	4	8,000
Aluminum foundries	5	1,000
Blast furnaces, steelworks	250	250
Petroleum refining	142	174

Release Patterns

Beryllium is concentrated in silicate minerals relative to sulfides and in feldspar minerals relative to ferromagnesium minerals. The greatest known naturally occurring concentrations of beryllium are found in certain pegmatite bodies. Certain fossil fuels contain beryllium compounds, perhaps accounting for its presence in some community air samples. Beryllium is not likely to be found in natural water above trace levels due to the insolubility of oxides and hydroxides at the normal pH range. It has been reported to occur in US drinking water at 0.01 to 0.7 ug/L.

Beryllium enters the environment principally from coal combustion. Beryllium content of the ashes and wastewater from a power plant suggest that secondary long term beryllium pollution emerges from the slag and ash dumps. It is also found in discharges from other industrial and municipal operations. Rocket exhaust products also consist of its compounds, principally the oxide, fluoride and chloride.

From 1987 to 1993, according to the Toxics Release Inventory beryllium releases to land and water totalled over 340,000 lbs., of which most was to land. These releases were primarily from copper rolling and drawing industries which use it as a hardener in alloys. The largest releases occurred in Pennsylvania and Ohio.

Environmental Fate

There is little information available on the environmental fate of beryllium and its compounds. Beryllium compounds of very low water solubility appear to predominate in soils. Leaching and transport through soils to ground water appears unlikely to be of concern. Erosion and bulk transport of soil may bring beryllium to surface waters, but most likely in particulate rather than dissolved form.

Other Regulatory Information

Monitoring:

- For Ground Water Sources:
  Initial Frequency- 1 sample once every 3 years
  Repeat Frequency- If no detections for 3 rounds, once every 9 years
- For Surface Water Sources:
  Initial Frequency- 1 sample annually
  Repeat Frequency- If no detections for 3 rounds, once every 9 years
- Triggers - If detect at > 0.004 mg/L, sample quarterly.

Analysis:

Reference Source	Method Numbers
EPA 600/4-79-020	210.2
NTIS PB 91-231498	200.7; 200.8; 200.9
ASTM	D3645-84B
Standard Methods	3113; 3120

Treatment

Best Available Technologies

Activated Alumina; Coagulation/filtration; Ion Exchange, Lime Softening, Reverse Osmosis

For Additional Information:

♦ EPA can provide further regulatory and other general information:
· EPA Safe Drinking Water Hotline - 800/426-4791
♦ Other sources of toxicological and environmental fate data include:
· Toxic Substance Control Act Information Line - 202/554-1404
· Toxics Release Inventory, National Library of Medicine - 301/496-6531
· Agency for Toxic Substances and Disease Registry - 404/639-6000

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Cyanide

CHEMICAL/ PHYSICAL PROPERTIES

CAS NUMBER: Hydrogen cyanide- 74-90-8

COLOR/ FORM/ODOR: Cyanide is a carbon-nitrogen chemical unit which may be combined with a variety of organic and inorganic components. The most common is hydrogen cyanide, a colorless, flammable liquid or gas.

SOIL SORPTION COEFFICIENT: Kocs of 1 to 70 for most soluble forms, with the nitriles having highest mobility in soils. Insoluble forms are expected to adsorb to sediments.

CYANIDE-CONTAINING COMPOUNDS:

Organics: Nitriles like Acetonitrile, butanenitrile, etc; bromoxynil, cyanocobalamin, cyanogens, cyanohydrins, tabun

Inorganics: combined with hydrogen, calcium, barium, sodium, zinc, nickel, mercury, potassium, copper, silver

BIOCONCENTRATION FACTOR: BCFs of <1 to 50 for most soluble forms, which are not expected to bioconcentrate in aquatic organisms. Insoluble forms may bioconcentrate.

SOLUBILITIES:

nitriles	low to moderate
cyanohydrin	highly soluble
cyanogens	moderate to high
tabun	soluble
other organics	slightly soluble
Hydrogen	soluble
sodium	48% at 10 deg C
potassium	50% in cold water
mercuric	10% at 14 deg C
barium	80% at 14 deg C
calcium	soluble
copper	insoluble

DRINKING WATER STANDARDS

MCLG:	0.2 mg/l
MCL:	0.2 mg/l
HAL(child):	1- to 10-day: 0.2 mg/L
	Longer-term: 0.2 mg/L

HEALTH EFFECTS SUMMARY

Acute: EPA has found cyanide compounds to potentially cause the following health effects from acute exposures at levels above the MCL: rapid breathing, tremors and other neurological effects.

Short-term exposures in drinking water considered "safe" for a 10-kg (22 lb.) child consuming one liter of water per day: upto a 7-year exposure to 0.2 mg/L.

Chronic: Cyanide compounds have the potential to cause the following chronic health effects from long-term exposures at levels above the MCL: weight loss, thyroid effects, nerve damage.

Cancer: There is inadequate evidence to state whether or not cyanide compounds have the potential to cause cancer from lifetime exposures in drinking water.

USAGE PATTERNS

The most commonly used form, hydrogen cyanide, is mainly used in manufacturing other cyanides, particularly adiponitrile which is used in nylon, and acrylonitrile - used in acrylic/modacrylic fibers and resins. Other cyanides such as dichlobenil, bromoxynil and bantrol, are used as herbicides. Tabun is used as a chemical warfare agent. Potassium cyanide is used for silver plating and for dyes and specialty products.

Available production data on cyanides: hydrogen cyanide, 1 billion lbs. in 1987; acrylonitrile-2.5 billion lbs. 1993; adiponitrile-1.4 billion lbs. in 1991; bromoxynil-2.6 million lbs in 1990; acetonitrile-35 million lb. in 1989.

TOXIC RELEASE INVENTORY - RELEASES TO WATER AND LAND: 1987 TO 1993

	Water	*Land*
TOTALS (in pounds)	939,611	641,082
Top Ten States *		
CA	0	430,886
PA	208,239	4,909
IN	187,377	20,242
OH	160,203	850
TX	54,379	83,394
MD	89,438	23,503
Major Industries*		
Blast furnaces + steel	747,970	53,404
Metal heat treating	0	430,886
Ind organic chems	49,098	82,912
Plating + polishing	29,486	29,636

RELEASE PATTERNS

The major sources of cyanide releases to water are reported to be discharges from metal finishing industries, iron and steel mills, and organic chemical industries. Releases to soil appear to be primarily from disposal of cyanide wastes in landfills and the use of cyanide-containing road salts. Cyanide released to air from car exhaust is expected to exist almost entirely as hydrogen cyanide gas.

Some foods may also naturally contain cyanides, including lima beans and almonds. Chlorination treatment of some wastewaters can produce chloroacetonitriles as a by-product.

Cyanide has been found in drinking water at levels on the order of a few parts per billion.

From 1987 to 1993, according to the Toxics Release Inventory cyanide compound releases to land and water totalled about 1.5 million lbs., of which about 65 percent was to water. These releases were primarily from steel mills and metal heat treating industries. The largest releases occurred in California and Pennsylvania.

ENVIRONMENTAL FATE

Nitriles are generally highly volatile and biodegradable when released to water, and are not expected to bioconcentrate in aquatic organisms. Nitriles have the potential to leach to ground water as they do not adsorb to soil. They tend to be resistant to hydrolysis in soil or water.

Cyanide-containing herbicides have more moderate potential for leaching, but again are readily biodegraded so they are not expected to bioconcentrate.

Soluble cyanide compounds such as hydrogen and potassium cyanide have low adsorption to soils with high pH, high carbonate and low clay content. However, at pH less than 9.2, most free cyanide is expected to convert to hydrogen cyanide which is highly volatile. Soluble cyanides are not expected to bioconcentrate.

Insoluble cyanide compounds such as the copper and silver salts may adsorb to soils and sediments, and generally have the potential to bioconcentrate. Insoluble forms do not biodegrade to hydrogen cyanide.

Tabun is rapidly hydrolyzed in soil and water, and so is not expected to leach or bioconcentrate.

OTHER REGULATORY INFORMATION

MONITORING:

- FOR GROUND WATER SOURCES:
  - INITIAL FREQUENCY- 1 sample once every 3 years
  - REPEAT FREQUENCY- If no detections for 3 rounds, once every 9 years
- FOR SURFACE WATER SOURCES:
  - INITIAL FREQUENCY- 1 sample annually
  - REPEAT FREQUENCY- If no detections for 3 rounds, once every 9 years
- TRIGGERS - If detect at > 0.2 mg/L, sample quarterly.

ANALYSIS:

REFERENCE SOURCE	METHOD NUMBERS
EPA 600/4-79-020	335.1*; 335.2; 335.3
NTIS PB 91-231498	D2036-89A; D2036-89B*
Standard Methods	4500-CN-D,E&,F; 4500-CN-G*

*- measure "free" or amenable cyanide; other methods screen for "total" cyanide.

TREATMENT

BEST AVAILABLE TECHNOLOGIES

Ion Exchange, Reverse Osmosis, Chlorine

FOR ADDITIONAL INFORMATION:

- EPA can provide further regulatory and other general information:
  - EPA Safe Drinking Water Hotline - 800/426-4791
- Other sources of toxicological and environmental fate data include:
  - Toxic Substance Control Act Information Line - 202/554-1404
  - Toxics Release Inventory, National Library of Medicine - 301/496-6531
  - Agency for Toxic Substances and Disease Registry - 404/639-6000

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Nickel

CHEMICAL/ PHYSICAL PROPERTIES

CAS NUMBER: 7440-02-0
COLOR/ FORM/ODOR: Nickel is a silvery metal found only in combined form in nature.
SOIL SORPTION COEFFICIENT: N/A; sorption related to that of iron/ manganese oxides, organic matter.
BIOCONCENTRATION FACTOR: N/A; not expected to bioconcentrate
COMMON ORES: sulfide- chalcopyrite, heazlewoodite (disulfide); sulfate- morenosite; carbonate- zaratite; oxide- bunsenite; others- pyrrhotite, pentlandite, garnierite, niccolite, millerite

SOLUBILITIES:

acetate-	17% at 65 deg C
carbonate-	93 mg/L at 25 deg C
carbonyl-	insoluble
chloride-	642 g/L at 20 deg C
cyanide-	insoluble
disulfide-	insoluble
fluoride-	40 g/L at 25 deg C
hydroxide-	0.13 g/L cold water
iodide-	1242 g/L at 0 deg C
nitrate-	48.5 Wt% at 20 deg C
oxide-	0.11 mg/L at 20 deg C
sulfate-	293 g/L at 0 deg C

DRINKING WATER STANDARDS

MCLG:	0.1 mg/l
MCL:	0.1 mg/l
HAL(child):	1- to 10-day: 1 mg/L
	Longer-term: 0.5 mg/L

NOTE: The MCLG and MCL for nickel are being remanded.

HEALTH EFFECTS SUMMARY

Acute: EPA has not found nickel to potentially cause health effects from acute exposures at levels above the MCL.

Short-term exposures in drinking water considered "safe" for a 10-kg (22 lb.) child consuming one liter of water per day: a one- to ten-day exposure to 1 mg/L; upto a 7 year exposure to 0.5 mg/L.

Chronic: Nickel has the potential to cause the following health effects from long-term exposures at levels above the MCL: decreased body weight; heart and liver damage; dermatitis.

Cancer: There is no evidence that nickel has the potential to cause cancer from lifetime exposures in drinking water.

USAGE PATTERNS

Production of nickel was 84.6 million lbs. in 1986, down slightly from 1982 report of almost 90 million lbs. [illegible] 1986 it was estimated that industries consumed nickel as follows: transportation, 25%, chemical industry, 15%; electrical equipment, 9%; construction, 9%; fabricated metal products, 9%; petroleum, 8%; household appliances, 7%; machinery, 7%; and other, 11%.

TOXIC RELEASE INVENTORY - RELEASES TO WATER AND LAND: 1987 TO 1993

	Water	*Land*
TOTALS (in pounds)	709,236	26,079,419
Top Ten States*		
OR	459	6,256,532
AR	4,250	5,622,900
ID	1,000	2,200,250
IN	28,050	2,098,196
PA	19,680	2,052,736
AZ	767	984,817
TX	0	777,400
MD	77,200	666,637
CA	6,687	285,731
GA	61,100	193,111
Major Industries*		
Primary nonferrous meta	16,874	12,053,688
Blast furnaces + steel	304,891	6,784,227
Ind inorganic chems	22,689	2,519,468
Ind organic chems	109,141	1,105,934
Petroleum refining	186,499	949,411
Primary copper	1,272	996,817
Iron+steel foundries	500	409,000
Gray iron foundries	3,326	334,524
Inorganic pigments	62,394	193,111

* Water/Land totals only include facilities with releases greater than a certain amount - usually 1000 to 10,000 lbs.

Nickel carbonate is used in nickel catalyst production for organic chemical manufacture, petroleum refining and edible oil hardening. Nickel oxide consumption in 1972 (representing over 30 million lbs. contained nickel) is estimated to have been as follows: 60% for stainless and heat resisting steels, 27% for other steel alloys, 8% for other nickel alloys, 2% for cast irons, and 3% for other uses.

RELEASE PATTERNS

Nickel is found in many ores as sulfides, arsenides, antimonides & oxides or silicates; chief sources include chalcopyrite; others are pyrrhotite, pentlandite, garnierite, niccolite, millerite. The principal natural form of nickel oxide occurs in admixture with nickel sulfides in varying proportions in weathered ore. Nickel carbonate, found as the mineral zaratite, is a potential atmospheric and surface water pollutant.

Inadvertent formation of nickel carbonyl can occur in various industrial processes that use nickel catalysts, such as coal gasification, petroleum refining, and hydrogenation of fats and oils. Nickel oxide has been identified in residual fuel oil and in atmospheric emissions from nickel refineries. Trinickel disulfide is a major component in nickel refinery flue dust.

From 1987 to 1993, according to the Toxics Release Inventory nickel releases to land and water totalled nearly 27 million lbs., of which most was to land. These releases were primarily from nickel smelting/refining and steelworks industries. The largest releases occurred in Oregon and Arkansas. The largest direct releases to water occurred in Maryland and Georgia.

ENVIRONMENTAL FATE

Nickel is one of the most mobile of the heavy metals in the aquatic environment. The mobility of nickel in the aquatic environment is controlled largely by the capability of various sorbents to scavenge it from solution. Although data are limited, it appears that in pristine environments, hydrous oxides of iron and manganese control nickel's mobility via co-precipitation and sorption. In polluted environments, the more prevalent organic material will keep nickel soluble. In reducing environments, insoluble nickel sulfide may be formed. Nickel chloride is water soluble and would be expected to release divalent nickel into the water.

The atmosphere is a major conduit for nickel as particulate matter. Contributions to atmospheric loading come from both natural sources and anthropogenic activity, with input from both stationary and mobile sources. Various dry and wet precipitation processes remove particulate matter as wash out or fallout from the atmosphere with transfer to soils and waters. Soil borne nickel may enter waters by surface runoff or by percolation into ground water.

Once nickel is in surface and ground water systems, physical and chemical interactions (complexation, precipitation/dissolution, adsorption/desorption, and oxidation/reduction) occur that will determine its fate and that of its constituents.

The only gaseous nickel compound of environmental importance is nickel carbonyl. Under ambient conditions in moist air, it decomposes to form nickel carbonate. Thus, in the atmosphere at concentrations near the ppb level, it has a half-life of about 30 minutes. The removal of nickel carbonyl by precipitation or by adsorption on surfaces has not been documented. Since this compound is soluble in water, precipitation scavenging is possible. Nothing is known about its reaction with natural surfaces or its uptake by vegetation. Thus, dry deposition rates cannot be predicted until some experimental investigations have been conducted.

Although nickel is bioaccumulated, the concentration factors are such as to suggest that partitioning into the biota is not a dominant fate process.

OTHER REGULATORY INFORMATION

MONITORING:

- FOR GROUND WATER SOURCES:
  - INITIAL FREQUENCY- 1 sample once every 3 years
  - REPEAT FREQUENCY- If no detections for 3 rounds, once every 9 years
- FOR SURFACE WATER SOURCES:
  - INITIAL FREQUENCY- 1 sample annually
  - REPEAT FREQUENCY- If no detections for 3 rounds, once every 9 years
- TRIGGERS - If detect at > 0.1 mg/L, sample quarterly.

ANALYSIS:

REFERENCE SOURCE	METHOD NUMBERS
EPA 600/4-79-020	249.1; 249.1
NTIS PB 91-231498	200.7; 200.8; 200.9
Standard Methods	3111B; 3113; 3120

TREATMENT

BEST AVAILABLE TECHNOLOGIES

Ion Exchange, Lime Softening, Reverse Osmosis

FOR ADDITIONAL INFORMATION:

- EPA can provide further regulatory and other general information:
- EPA Safe Drinking Water Hotline - 800/426-4791
- Other sources of toxicological and environmental fate data include:
- Toxic Substance Control Act Information Line - 202/554-1404
- Toxics Release Inventory, National Library of Medicine - 301/496-6531
- Agency for Toxic Substances and Disease Registry - 404/639-6000

United States Environmental Protection Agency
Office of Water 4601
EPA 811-F-95-002n-T
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EPA

National Primary Drinking Water Regulations

Thallium

CHEMICAL/ PHYSICAL PROPERTIES

CAS NUMBER: 7440-28-0 (metal)

COLOR/ FORM/ODOR: Thallium is a metallic element that exists in nature only in as salts and other combined forms.

SOIL SORPTION COEFFICIENT: N/A; strongly adsorbed to some clays at alkaline pH.

BIOCONCENTRATION FACTOR: Log BCFs = 5 to 5.2 in fish, invertebrates; expected to bioconcentrate

SOLUBILITIES:

acetate	very soluble
carbonate-	4% (w/w) cold water
chloride-	2.9 g/L at 15.5 deg C
nitrate-	39.1 g/L to 95.5 g/L at 20 deg C
oxide-	insoluble
sulfate-	48.7 g/L at 20 deg C

COMMON ORES: Thallium is a trace metal associated with potassium in copper, gold, zinc, and cadmium ores.

DRINKING WATER STANDARDS

MCLG:	0.0005 mg/l
MCL:	0.002 mg/l
HAL(child):	1- to 10-day: 0.007 mg/L
	Longer-term: 0.007 mg/L

HEALTH EFFECTS SUMMARY

Acute: EPA has found thallium to potentially cause the following health effects from acute exposures at levels above the MCL: gastrointestinal irritation; peripheral neuropathy.

Short-term exposures considered "safe" for a 10-kg (22 lb.) child consuming one liter of water per day: upto a 7-year exposure to 0.007 mg/L.

Chronic: Thallium has the potential to cause the following health effects from long-term exposures at levels above the MCL: changes in blood chemistry; damage to liver, kidney, intestinal and testicular tissues; hair loss.

Cancer: There is no evidence that thallium has the potential to cause cancer from lifetime exposures in drinking water.

USAGE PATTERNS

There is no domestic production of thallium. Approximately 4,500 lbs. of thallium and its compounds were imported in 1987. In 1984, US industry consumed thallium compounds as follows: electronics industry, 60-70%; the remainder was used in pharmaceuticals, alloys and glass manufacture.

Thallium compounds are used in infrared spectrometers, in crystals, in other optical systems, and for coloring glass; in semiconductor research; with mercury for switches and closures which operate at subzero temperatures; in photoelectric cells, lamps, and, in electronics, in scintillation counters; as catalyst in organic synthesis; as a rat poison, as an ant bait, and as a reagent in analytical chemistry. It was also formerly used as a depilating agent by dermatologists and as a cosmetic depilatory cream.

RELEASE PATTERNS

In nature, thallium is present as a trace compound in many minerals, mainly associated with potassium and rubidium.

Man-made sources of thallium pollution are gaseous emission of cement factories, coal burning power plants,

TOXIC RELEASE INVENTORY - RELEASES TO WATER AND LAND: 1987 TO 1993

	Water	*Land*
TOTALS (in pounds)	2,606	2,770
Top Five States		
TX	6	2,020
OH	1,500	0
MN	1,100	0
CO	0	500
IN	0	250
Major Industries*		
Primary copper smelting	1,856	765
Petroleum refining	750	1,255
Primary nonferrous metals	0	500
Blast furnaces, steelworks	0	250

and metal sewers. The leaching of thallium from ore processing operations is the major source of elevated thallium concentrations in water. Thallium is a trace metal associated with copper, gold, zinc, and cadmium.

Water concentrations of 1 to 88 parts per billion have been reported in rivers draining metal mining areas.

From 1987 to 1993, according to the Toxics Release Inventory thallium releases to land and water totalled over 5,000 lbs., of which about half was to water. These releases were primarily from copper smelting and petroleum refining industries. The largest releases occurred in Texas and Ohio.

ENVIRONMENTAL FATE

In a study of thallium movement in a simple aquatic ecosystem, concentrations of thallium decrease slowly in the water and increase tenfold in the vegetation and fish. Definite transport of thallium occurred among water, fish, and vegetation, but no transport was seen between the sand other ecosystem components.

It was found that increasing pH decreased thallium-inorganic interactions. Increases in pH, however, produced extensive thallium-humic acid interaction. It appears that thallium-organic interactions may be important in most natural water systems.

In reducing environments, thallous species may precipitate as a sulfide; otherwise, it will remain in solution.

Thallium sulfate has been used as a rodenticide in Japan, where it was sprayed over forest areas, but was not found to persist in water for more than a month. Since thallium is soluble in most aquatic systems, it is readily available to aquatic organisms and is quickly bioaccumulated. Goldfish have a higher rate of uptake for thallium than for the five most common alkali metals. Some algae are able to concentrate thallium by a factor of 127 to 220 within one hour; in comparison, the concentration factors of 2.7 hours exposure were 114 for lead, 30 for cadmium, 80 for zinc, and 313 for copper.

Bioconcentration factors: in freshwater fish, factor of 100,000; in marine invertebrates, factor of 150,000; in marine fish, factor of 100,000; in freshwater and marine plants, factor of 100,000; in clams (Mya arenia), factor of 17.6-18.6; in mussel (Mytilus edulis), factor of 10.9-12.4; and in Atlantic salmon, factor of 27-1430.

OTHER REGULATORY INFORMATION

MONITORING:

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- FOR SURFACE WATER SOURCES:
  - INITIAL FREQUENCY- 1 sample annually
  - REPEAT FREQUENCY- If no detections for 3 rounds, once every 9 years
- TRIGGERS - If detect at > 0.002 mg/L, sample quarterly.

ANALYSIS:

REFERENCE SOURCE	METHOD NUMBERS
EPA 600/4-79-020	279.2
NTIS PB 91-231498	200.8; 200.9
Standard Methods	3113; 3113B

TREATMENT

BEST AVAILABLE TECHNOLOGIES

Activated alumina; Ion Exchange

FOR ADDITIONAL INFORMATION:

♦ EPA can provide further regulatory and other general Information:

- EPA Safe Drinking Water Hotline - 800/426-4791

♦ Other sources of toxicological and environmental fate data include:

- Toxic Substance Control Act Information Line - 202/554-1404
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