Ministerio del Medio Ambiente

Gobierno de Chile

PRODUCTS WITH ADDED MERCURY AND RISKS FOR THE ENVIRONMENT AND HEALTH

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PURPOSE OF THE TECHNICAL GUIDE

This technical guide is intended to educate and provide general information on everyday products that contain added mercury such as batteries, bulbs, thermometers, medical devices, creams, etc. In addition, the guide provides information on products that fulfill the same function as the previous, but that are mercury-free.

The guide also briefly describes the risks that mercury can cause people´s health and the environment, the management and prevention measures that can be adopted in homes. Finally, the Minamata Convention is described and how this international environmental convention generates a regulatory framework for products with added mercury.

WHO SHOULD READ THIS GUIDE?

The guide should be read by people who wish to learn about Mercury in everyday consumer products and who want to know the risks that this metal could generate on the environment and human health.

SOURCES OF INFORMATION

This technical guide has been prepared using public information available on the internet and websites of the United States Environmental Protection Agency (EPA), Ministry of Environment-Government of Japan, UN Environment, Secretary of the Minamata Convention, and non-profit organizations such as Biodiversity Research Institute and Zero Mercury Working Group.

AUTHOR

MSc. Cristian Brito Martinez, Ministry of Environment, Chile

World-class environmental expert with 15 years of experience leading environmental projects in the private sector and government. He is the expert appointed by Chile to the UN Environment and OECD for environmental risk management, marine debris, and Minamata Convention on mercury. Cristian has strong interest in AI for the study of Environmental Risks and Environmental Compliance.

DESIGN

Alejandro Armendariz, Ministry of Environment, Chile

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1.- Mercury

Mercury is achemical element with the symbol Hg. Mercury is a metal found naturally in the earth's crust in the form of cinnabar (HgS) and as an by product in coal, oil and natural gas deposits. It is the only metal that at room temperature can be found in its liquid state and easily forms alloys with other metals such as silver and gold producing amalgams.

Mercury has no known metabolic functions and is highly toxic to living organisms. In humans, it can cause negative effects on the central nervous system and other vital organs[1]

Figure 1:
Cinnabar (HgS).

Source: By JJ Harrison (https://www.jjharrison.com.au/)

Mercury can be found mainly in three ways:

- Elemental Mercury (metallic).
- Inorganic mercury compounds.
- Methylmercury and other organic compounds,

Elemental mercury (Hg^0) is a bright silver metal that can evaporate at room temperature and produce highly toxic vapors. It is produced by heating the cinnabar ore above 650 °C, where the ore decomposes into sulfur dioxide (SO_2) and metallic mercury.

Figure 2:
Elemental Mercury (Hg^0)

Inorganic mercury compounds are produced by the reaction of elemental mercury with other chemical elements such as oxygen, sulfur and chlorine, producing salts such as mercury chloride ($HgCl_2$).

Figure 3:
Mercury Salts ($HgCl_2$)

Source: https://commons.wikimedia.org/wiki/File:Mercury_Chloride.jpg

Methylmercury and other organic mercury compounds are formed when mercury reacts with carbon compounds; this process is catalyzed by the action of microorganisms present in water.

Table 1:
Physical and chemical properties of mercury

Chemical Symbol	Hg
CAS Number	7439-97-6
Atomic Number	80
Mass Number	200,59
Density (at 20 °C)	13,534 g/cm^3
Solubility	Not soluble in water
Melting Point	-38,82 °C
Steam Pressure (at 25 °C)	0,00185 mm
Boiling Point	356,73 °C

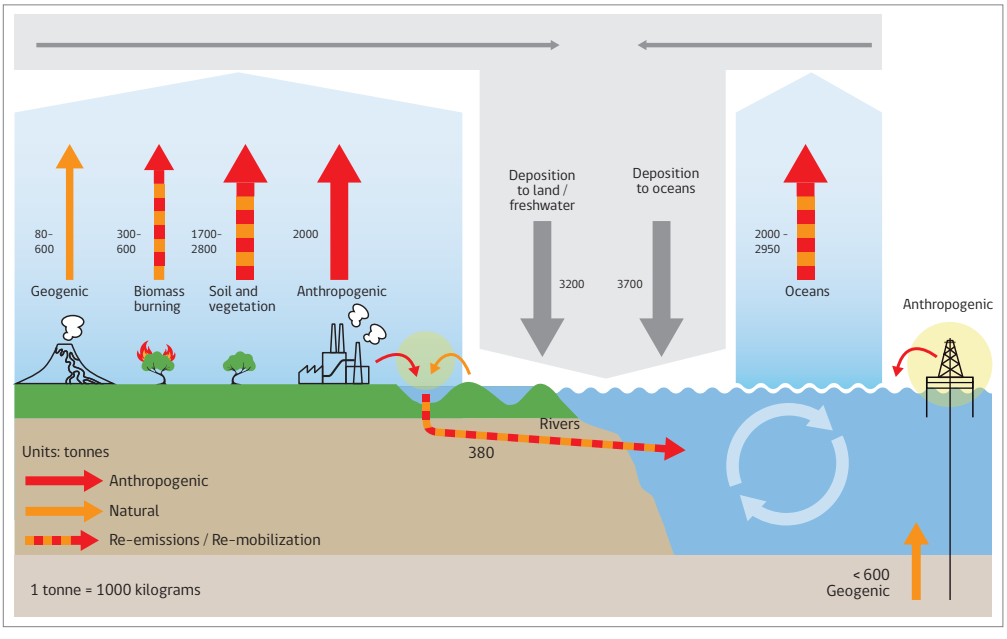
2.–MERCURY AND ENVIRONMENT

Mercury is a natural constituent of the Earth's crust and can be released into the environment from several natural sources. It can also be released from anthropogenic sources such as mercury-containing thermometers that, when broken, disperse this metal.

Once the mercury enters the environment it persists for long periods of time and only changes shape circulating between the air, water, soil and biota. Eventually it can be removed from the system by depositing it in sediments in the ocean or lakes and by trapping it in stable mineral compounds such as cinnabar.

Once deposited in the environment, naturally present microorganisms can change mercury to methyl mercury, a particularly hazardous form that concentrates up food chains in a process called biomagnification. Methyl mercury is the most toxic form of mercury and it presents the greatest health risk to humans and wildlife (UN Environment).

Figure 4:
Global Mercury Cycling



Source: http://mercurylearn.unitar.org/

2.1. Natural Sources of Mercury

These releases occur due to the natural mobilization of mercury naturally occurring in the Earth's crust, such as volcanic activity and weathering of rocks.

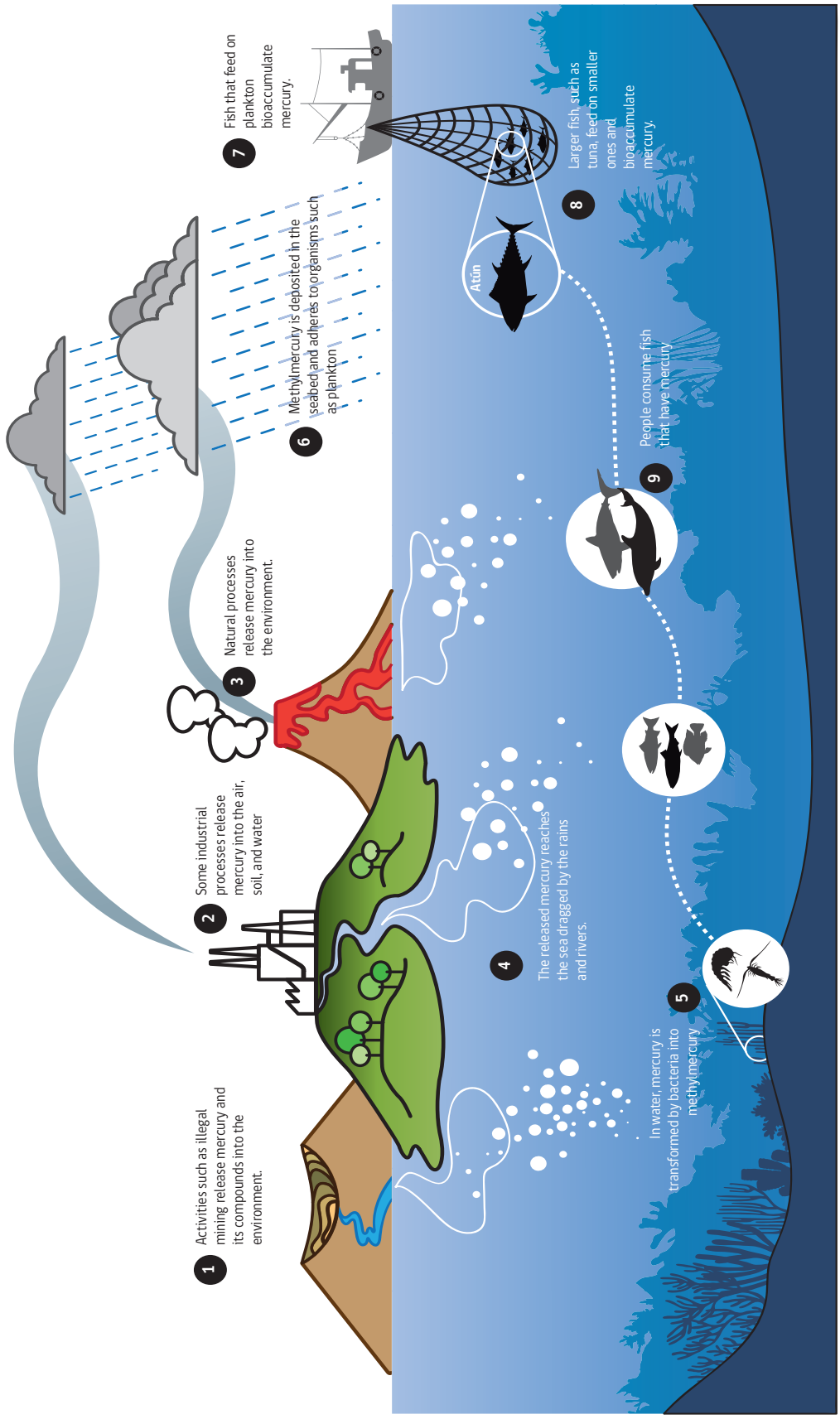
Figure 5:
View of an eruption column from Chaiten Volcano, Chile

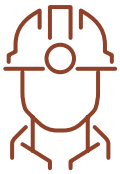
2.2. Anthropogenic sources of mercury

Human activity has considerably increased the amount of mercury that is released into the environment and that comes mainly from the following sources:

1. **mobilization of mercury impurities in raw materials**
2. **intentional use of mercury in products and processes**
3. **re-mobilization of previous anthropogenic mercury releases**

Figure 6:
The Bioaccumulation of Methylmercury





3.- MERCURY USES

Due to its physical and chemical properties such as water insolubility, electrical conductivity or facility to form alloys, mercury has been used since ancient times in a great variety of sectors and productive processes such as[2]:

Chlor-alkali production with mercury technology

In the chemical industry, mercury has been used as a catalyst in the process called chlor-alkali, where chlorine is obtained through the use of mercury cathodes.

VCM (vinyl-chloride-monomer) production with mercury-dichloride (HgCl2) as catalyst

Two processes are used to manufacture vinyl chloride: the acetylene process uses mercuric chloride on carbon pellets as a catalyst, and the other is based on the oxychlorination of ethylene (without mercury use).

Acetaldehyde production with mercury-sulphate ($HgSO_4$) as catalyst

Although alternative (non-mercury) processes are available and more common globally, mercury-sulphate can be used in the production of acetaldehyde.

Acetaldehyde production using mercury has been almost entirely abandoned. However, a limited number of companies in the world still use the technology. The mercury releases from this type of facility were well illustrated in the famous mercury pollution tragedy that occurred in 1950s-1960s in Minamata Bay Japan[2]

Dental amalgams

Dentistry has widely used mercury in the form of dental amalgams to treat tooth decay and other diseases. Because of its low price, this type of procedure is still widely used in the world, especially in developing countries.

Industrial products

Various products for industrial use and in the home contain mercury, for example: batteries, thermometers, manometers, barometers, paints, ampoules, electrical switches, medical devices, etc.

Personal care products

Nowadays mercury is still used in some types of whitening creams, which due to their low price are widely used. This metal is also used in the coating of mirrors and in some coloring dyes.

Artisanal and Small-Scale Gold and silver Mining

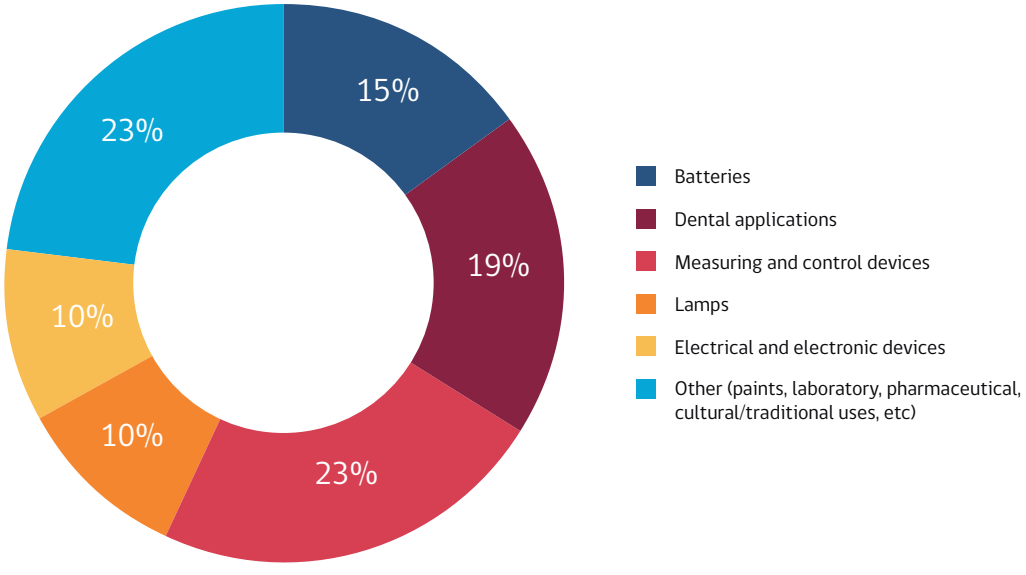
Due to its facility to produce alloys with other metals, elemental mercury is widely used by artisanal miners in gold and silver extraction processes. This is a highly risky activity since miners usually do not have safety measures that protect them from the toxic effects of mercury and do not have protective measures to prevent mercury being released into the environment.

4.- GLOBAL MERCURY TRADE

Mercury is used in a wide variety of industrial activities such as artisanal and small-scale gold mining (ASGM), vinyl chloride monomer (VCM) production, measuring and control devices, industrial products, chlor-alkali production, dental amalgams and batteries (UNEP 2019).

Approximately 57% of the world's mercury consumption is used in the sectors corresponding to the manufacture of measuring and control instruments, dental applications and in the manufacture of batteries[3].

Figure 7:
Global Mercury consumption by sector, products (2015)



Although the Global Mercury Market is dynamic and dependent on variations in the global economy, since 2013 there has been a decrease in the supply of mercury from chlor-alkali industry, this may be due to the restrictions that have been introduced to its export as a result of the implementation of the Minamata Convention.

Table 2:
Global Mercury Supply

Mercury Source	Min.Mercury Supply (tonnes)	Max.Mercury Supply (tonnes)
Primary (mined) mercury	1.630	2.150
By-products mercury	440	775
Chlor-alkali residual mercury	370	450
Mercury recycling	1.040	1.410
Total Supply	**3.480**	**4.785**

Source: Global mercury supply, 2015 (UNEP 2017, p.21)

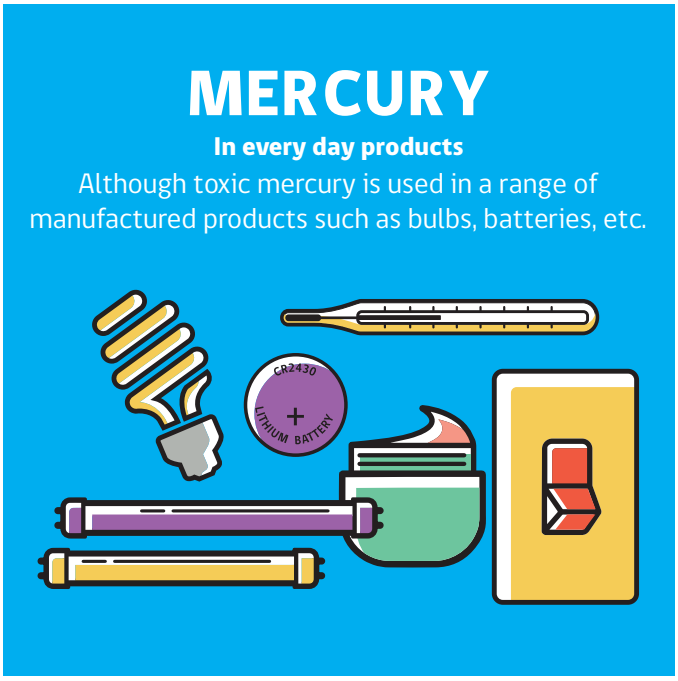
5.- PRODUCTS WITH ADDED MERCURY

A large number of traditional products make use of mercury's properties to support their function. The major products groups in which mercury is added intentionally are thermometers, fluorescent light bulbs, some battery types, some traditional types of electrical switches, and traditional manometers and pressure gauges[2].

The mercury contained in these products can be released to the environment in the following stages of the life cycle of these products:

1. During production of these products depending on how closed manufacturing systems are, and on the handling and workplace procedures in the individual production units;
2. By breakage of a product (to air, water, soil) during use;
3. During disposal of the products after their use (directly to soil, to landfills or waste incineration and subsequently to water and air), closely depending on types and efficiency of employed waste collection and handling procedures.

Figure 8:
Mercury in products[4].



DETAIL OF THE MAIN PRODUCTS FOR INDUSTRIAL AND DOMESTIC USE THAT CONTAIN ADDED MERCURY[5]

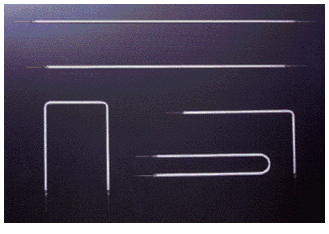
- Primary batteries (limited to: alkaline button batteries, mercury batteries, zinc-air batteries, silver-oxide batteries, manganese dry-cell batteries, and alkaline dry-cell batteries)
- Standard cells
- Switches/relays
- Fluorescent lamps (including cold cathode fluorescent lamps- CCFL, and external electrode fluorescent lamps- EEFL)
- High-intensity discharge (HID) lamps
- Discharge lamps (excluding fluorescent lamps and HID lamps)
- Cosmetic products
- Agricultural chemicals
- Pesticide, biocide, topical antiseptics (excluding pharmaceutical products and agricultural chemicals)
- Barometers
- Hygrometers
- Liquid manometers
- Elastic manometers (limited to diaphragm type)
- Pressure transmitters (limited to diaphragm type)
- Vacuum gauges
- Glass thermometers
- Mercury-filled pressure thermometers
- Mercury clinical thermometers
- Mercury sphygmomanometers
- Temperature fixed-point cells
- Rubber
- Pigment
- Perfume
- Detonators
- Fireworks
- Paints
- Daguerreotypes
- Mercury alloy pellets and powder
- Boilers (limited to those used in a two phase fluid cycle)
- Rotating lens assembly of a lighthouse
- Diffusion pumps
- Pressure relief devices
- Dampers
- Mercury trim and heel adjusting devices
- Discharge tubes (excluding discharge lamps including fluorescent/HID lamps)
- X-ray tubes
- Mercury resistance standards
- Rotary connectors
- Infrared detection elements
- Differential pressure flowmeters
- Float type densitometers
- Clinometers
- Porosimeters
- Frequency standards
- Radiation detectors
- Detector tubes
- Gas analyzers (excluding those using mercury as reference standard)
- Elapsed time indicators
- Volume type power meters
- Strain gauge sensors
- Dropping mercury electrode
- Coulometers
- Reference electrodes
- Mercury vapor generators (limited to those vaporizing enclosed mercury by heating or reduction)
- gyrocompasses
- Mirrors
- Grip dynamometers
- Pharmaceutical products
- Polishing agents
- Arts and crafts
- Formulation of mercury2
- Formulation of mercury (I) chloride
- Formulation of mercury (II) chloride
- Formulation of mercury (II) iodide
- Formulation of mercury (I) nitrate
- Formulation of mercury (II) nitrate
- Formulation of mercury (II) thiocyanate
- Formulation of phenylmercury

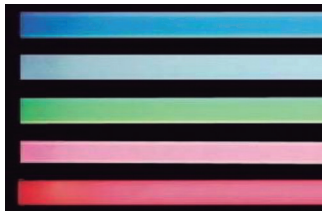
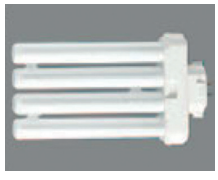
5.1. Lamps (Light sources with mercury)

Mercury is used in small amounts per lamp in a number of different types of discharge lamps, with fluorescent tubes and compact fluorescent lamps (CFLs) as the most common examples. Other light sources reported to contain mercury include: high-pressure mercury vapour lamps, high-pressure sodium lamps, UV light for tanning, metal halide lamps, specialty lamps for chemical analysis, and backlights for computer and TV flat-screens.

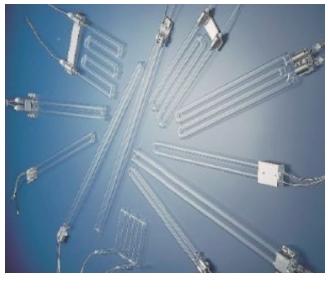
Table 3:
Light sources with mercury[5]

Type	Product	Example of products in which the products in the left column are used and assembled
Fluorescent lamps including straight tube type, circular type, square type, compact type, and self-ballasted type	Straight tube type (10-20W)  Circular type  Square type  Compact type (not more than 27W) 	General lighting equipment

Type	Product	Example of products in which the products in the left column are used and assembled
Fluorescent lamps including straight tube type, circular type, square type, compact type, and self-ballasted type	Self-ballasted type   	General lighting equipment
Cold Cathode Fluorescent Lamps (CCFL) and External Electrode Florescent Lamps (EEFL)	CCFL and EEFL  Note: CCFL and EEFL are disposed of as assembled into products such as liquid crystal display televisions.	Liquid crystal display televisions, liquid crystal displays, scanners, copiers, car navigation equipment
Fluorescent lamps including straight tube type, compact type, electrodeless fluorescent type, and specially-shaped type **Straight tube type**	For general lighting purposes (4-8W) (30-110W)  Lamps for cleaning rooms of semiconductor factories  Black lights 	<u>For general lighting purposes</u> General lighting equipment <u>For special purposes</u> Lighting for art museums and museums, lighting for goods and food display, fluorescent lighting, insect traps, medical devices, tanning machines, lighting for semiconductor factories, lighting for agricultural cultivation facilities such as glass greenhouses, printing machines for diazo papers and blueprint sensitized papers, emergency lights, guiding lights, aeronautical lights

Type	Product	Example of products in which the products in the left column are used and assembled
Fluorescent lamps including straight tube type, compact type, electrodeless fluorescent type, and specially-shaped type **Straight tube type**	Color lamps  Compact type fluorescent lamps (equal to or more than 28W) (The first alphabet of the item number is "F".)  Electrodeless fluorescent lamps  	<u>For general lighting purposes</u> General lighting equipment <u>For special purposes</u> Lighting for art museums and museums, lighting for goods and food display, fluorescent lighting, insect traps, medical devices, tanning machines, lighting for semiconductor factories, lighting for agricultural cultivation facilities such as glass greenhouses, printing machines for diazo papers and blueprint sensitized papers, emergency lights, guiding lights, aeronautical lights
HID lamps such as high pressure mercury lamps, metal-halide lamps, high pressure solid lamps, and mercury-xenon lamps (including medium pressure and ultra-high pressure lamps)	HID lamps for general lighting purposes High pressure mercury lamps   High pressure mercury lamps (ballastless)  	<u>For general lighting purposes</u> Lighting for road, park, stadium, and gymnasium, portable lighting <u>For special purposes</u> Lighting for art museums and museums, lighting for goods and food display, medical devices, tanning machines, lighting for squid fishing, fluorescent microscopes, ultraviolet curing/drying/bonding apparatus, semiconductor inspection apparatus, DNA analysis devices, semiconductor exposure apparatus, printed board exposure apparatus, headlight units (for automobiles, motorcycles, agricultural tractors, and railway vehicles), working lights (machines for construction and agriculture), sign lights, projectors, aeronautical lights, landscape lighting, stage lighting

Type	Product	Example of products in the left column are used and assembled
HID lamps such as high pressure mercury lamps, metal-halide lamps, high pressure solid lamps, and mercury-xenon lamps (including medium pressure and ultra-high pressure lamps)	Metal-halide lamps 	<u>For general lighting purposes</u> Lighting for road, park, stadium, and gymnasium, portable lighting <u>For special purposes</u> Lighting for art museums and museums, lighting for goods and food display, medical devices, tanning machines, lighting for squid fishing, fluorescent microscopes, ultraviolet curing/drying/bonding apparatus, semiconductor inspection apparatus, DNA analysis devices, semiconductor exposure apparatus, printed board exposure apparatus, headlight units (for automobiles, motorcycles, agricultural tractors, and railway vehicles), working lights (machines for construction and agriculture), sign lights, projectors, aeronautical lights, landscape lighting, stage lighting
	High pressure sodium lamps 	
	HID lamps for industrial use - Ultra-high pressure UV lamps 	
	- Lamps for projectors 	

Type	Product	Example of products in which the products in the left column are used and assembled
HID lamps such as high pressure mercury lamps, metal-halide lamps, high pressure solid lamps, and mercury-xenon lamps (including medium pressure and ultra-high pressure lamps)	Lamps for stage lighting  Lamps for floodlighting  Mercury-xenon lamps 	<u>For general lighting purposes</u> Lighting for road, park, stadium, and gymnasium, portable lighting <u>For the special purposes</u> Lighting for art museums and museums, lighting for goods and food display, medical devices, tanning machines, lighting for squid fishing, fluorescent microscopes, ultraviolet curing/drying/bonding apparatus, semiconductor inspection apparatus, DNA analysis devices, semiconductor exposure apparatus, printed board exposure apparatus, headlight units (for automobiles, motorcycles, agricultural tractors, and railway vehicles), working lights (machines for construction and agriculture), sign lights, projectors, aeronautical lights, landscape lighting, stage lighting
Low pressure mercury lamps other than fluorescent lamps including ultra violet radiation lamps, hollow cathode lamps, penray lamps, and electrodeless discharge lamps)	Germicidal lamps  Low pressure ultraviolet lamps  Ultraviolet radiation lamps 	Food production lines, water sterilizers, tanning machines, surface of glass plate for semiconductors and liquid-crystal displays, rinse. Water recycling equipment, ultrapure water making machines, ultraviolet curing apparatus, sterilizers, cleaners for decontamination of equipment, mercury measuring devices, atomic absorption photometry, atomic fluorospectro-photometers, TOC meters, measuring devices for the environmental monitoring (including total nitrogen meters, total phosphorus meters, ultraviolet absorption spectrophotometers, water contamination analyzers, and ozone concentration meters), emission spectrophotometric analyzers, high-performance liquid chromatography, ultraviolet visible spectrophotometry

Type	Product	Example of products in the left column are used and assembled
Low pressure mercury lamps other than fluorescent lamps including ultra violet radiation lamps, hollow cathode lamps, penray lamps, and electrodeless discharge lamps)	Mercury-xenon lamps  - Pen-ray lamps 	Food production lines, water sterilizers, tanning machines, surface of glass plate for semiconductors and liquid-crystal displays, rinse. Water recycling equipment, ultrapure water making machines, ultraviolet curing apparatus, sterilizers, cleaners for decontamination of equipment, mercury measuring devices, atomic absorption photometry, atomic fluorospectro-photometers, TOC meters, measuring devices for the environmental monitoring (including total nitrogen meters, total phosphorus meters, ultraviolet absorption spectrophotometers, water contamination analyzers, and ozone concentration meters), emission spectrophotometric analyzers, high-performance liquid chromatography, ultraviolet visible spectrophotometry

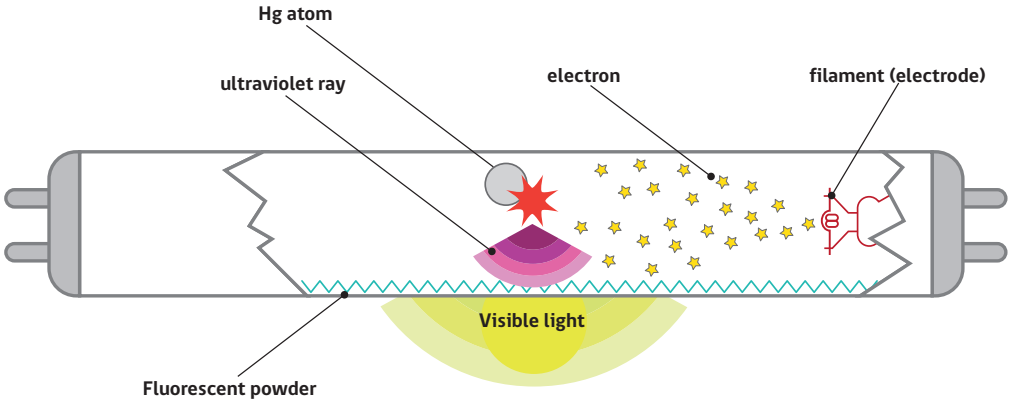
The mercury contained in these products can be released to the environment in the following way

Relevant life-cycle phases and expected release pathways[2]:

Life-cycle phase	Release pathway					
	Air	Water	Land	Products	General waste	Sector specific treatment/disposal
Production	**X**	**X**	**X**	**X**		**X**
Use	**X**	**X**	**X**			
Disposal	**X**		**X**		**X**	**X**

X = predominant release pathway, **X** = additional release pathway

Figure 9:
Example of the mercury use in a fluorescent lamp.



Source: http://nkcl.jp/mercury/mercury-in-products/

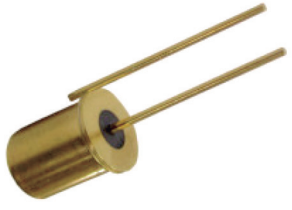
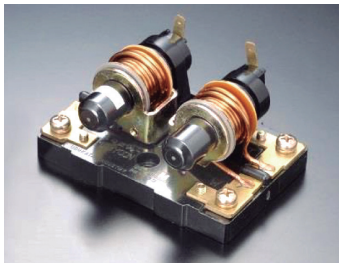
5.2. Electrical Switches and relays with mercury

Mercury has been used (and continues to be used) in a variety of electrical switches and relays. In some countries mercury in electrical components has been phased out and substituted by alternative non-mercury materials. However, the status and extent of substitution probably varies considerably between countries.

Moreover, regardless of status of substitution, mercury switches and relays will likely be present in waste for years to come due to very long service life of these items.

Table 4:
Electrical switches with mercury[5]

Type	Product	Example of products in which the products in the left column are used and assembled
Electrical Switches and relays	Inclination switches 	‣ Outdoor gas fan heaters ‣ Medical devices (equipment for peritoneal dialysis)

Type	Product	Example of products in which the products in the left column are used and assembled
Electrical Switches and relays	Temperature switches 	Temperature sensors for petrochemical plants "A typical use is in a thermostat. A glass mercury switch is mounted to a bimetallic spring which expands and contracts with temperature."
	Electronic acceleration switches (G sensors) 	Seismoscopes
	Overcurrent protection switches 	Large-scale industrial equipment including railway vehicles, air-conditioners in commercial facilities, outdoor fan heaters, ultraviolet medical treatment devices, and mercury rectifiers
	Switches and relays for measurement, control, and transmission 	Electronic measuring instruments, monitoring and control equipment, noise simulators, signal generators, signal switches, medical devices (such as laser surgery devices, sterilizers, and dental units), modem, remote control and supervisory equipment, automatic system switching equipment, automatic train stop

The mercury contained in these products can be released to the environment in the following way

Relevant life-cycle phases and expected release pathways[2]

Life-cycle phase	Release pathway					
	Air	Water	Land	Products	General waste	Sector specific treatment/disposal
Production	X	X	X	X		X
Use	X	X	X			
Disposal	X		X		X	X

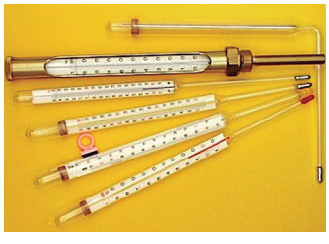
X = predominant release pathway, **X** = additional release pathway

5.3. Measuring devices (except for medical and household use)

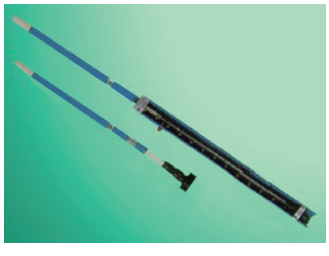
Mercury thermometers have traditionally been used for most medium temperature range measurements. Today they are increasingly substituted by electronic and other thermometer types, but the degree of substitution probably varies among countries.

Major remaining uses are medical thermometers (body temperature in hospitals, households, etc.), in chemical laboratories, ambient air temperature thermometers, in controls of some machines (large diesel engines) and industrial equipment. Mercury thermometers may contain between approximately 0.6 and several 100 grams of Hg/unit, depending on the type of thermometer.

Table 5:
Measuring devices with mercury[5]

Type	Product	Example of products in which the products in the left column are used and assembled
Mercury thermometers	Double-pipe precision thermometers 	Diesel engines, medical devices (gas sterilizers), pycnometers, flashing point testers

Type	Product	Example of products in which the products in the left column are used and assembled
Mercury thermometers	Mercury-filled pressure thermometers 	Diesel engines, machines for chemical fibers and chemical resin fibers, molding machines of gas generators
Mercury hydrometers	Assmann psychrometers 	Assmann psychrometers
	Mercury column manometers 	Machines for chemical fibers and chemical resin fibers, resin injection molding machines
Mercury manometers	Diaphragm manometers for high temperature 	
Electric diaphragm transmitters for high temperature	 	Machines for chemical fibers and chemical resin fibers, resin film and sheet manufacturing equipment, resin material and synthetic rubber manufacturing equipment

Type	Product	Example of products in which the products in the left column are used and assembled
Mercury coulometers		
Float type densitometers		
Mercury Tensiometer		The Mercury Tensiometer is particularly well suited for lighter or semi-heavy soils and/or water-sensitive crops because of its extreme rapid responses to changes in water-availabilty. The Mercury Tensiometer is also very accurate and provides refined reading values."

The mercury contained in these products can be released to the environment in the following way

Relevant life-cycle phases and expected release pathways[2]

Life-cycle phase	Release pathway					
	Air	Water	Land	Products	General waste	Sector specific treatment/disposal
Production	X	X	**X**	X		X
Use	X	X	**X**			
Disposal	X		X		X	**X**

X = predominant release pathway, **X** = additional release pathway

5.4. Dental mercury-amalgam fillings

Dental amalgam fillings consist of an alloy of mercury, silver, copper and tin (typically about 44-51% mercury by weight). The alloy is typically supplied to the dentists either: 1) as pure mercury along with a powder mix of the other metals, which are weighed and mixed in an agitator in the clinic; or 2) as small capsules where mercury and the metal powder are present in the right formula and only need to be mixed (in the capsule before opening) in the clinic, prior to filling the cavity in the tooth. Other variants of the same principles may occur.

Table 6:
Dental mercury-amalgam

Type	Product	Example of products in which the products in the left column are used and assembled
Dental amalgam		Dentistry

Mercury is released to air, water, and wastes during the production, use and disposal of the amalgam fillings (such as following the removal of fillings or teeth containing fillings during medical/dental procedures, or through lost teeth). Also, releases can occur at the end of life of a person with fillings. For example, dental amalgams are a major factor determining mercury releases to air from crematoria.

Relevant life-cycle phases and expected release pathways[2]

Life-cycle phase	Release pathway					
	Air	Water	Land	Products	General waste	Sector specific treatment/disposal
Production/supply materials for filling				X		**X**
Dental preparation and procedures at dental offices Use (while in people´s mouths)	**X**	X			X	X
Disposal		X			X	X

X = predominant release pathway, **X** = additional release pathway

5.5. Batteries with mercury

The use of mercury in various types of batteries has been extensive and it has been among the largest product uses of mercury. Mercury has mainly - or perhaps solely - been used in primary (that is, non-rechargeable) batteries.

Mercury is used in high concentrations (about 30-32% w/w) in mercury oxide batteries (sometimes called zinc-mercury batteries). In other battery types, any mercury use is usually in lower concentrations.

The use of mercury in other batteries has been gradually reduced over the last decades in global brands, but may be still used in some national/regional brands. Button-cell shaped batteries of alkaline, silver oxide, and zinc/air types normally still contain mercury in most cases, though mercury-free alternatives are now available. Note that besides plain battery sales, batteries may be imported and exported in substantial amounts in the package of other products like electronics, toys, greeting cards with sounds, etc.

Table 7:
Batteries with mercury[5]

Type	Product	Example of products in which the products in the left column are used and assembled
Batteries	Alkali button batteries (The first two alphabets of the item number are "LR" among button cells.) 	Quartz clocks (watch, clock), toys, pedometers, calculators, crime prevention buzzers, timers, household remote controllers, lightning ornaments and shoes, small lights, medical devices such as digital thermometers
	Silver-oxide batteries (The first two alphabets of the item number are "SR".) 	Quartz clocks (watch), medical devices such as digital thermometers

Type	Product	Example of products in which the products in the left column are used and assembled
Batteries	Zinc-air batteries (The first two alphabets of the item number are "PR", or those have an air hole.) 	Hearing aids, pagers
	Mercury batteries (The first two alphabets of the item number are "NR" or "MR".) 	Hearing aids, exposure meters of silver halide camera
	Dry cells 	Imported toys

The mercury contained in these products can be released to the environment in the following way

Relevant life-cycle phases and expected release pathways[2]:

Life-cycle phase	Release pathway					
	Air	Water	Land	Products	General waste	Sector specific treatment/disposal
Production	**X**	**X**	**X**	**X**		**X**
Use						
Disposal	**X**		**X**		**X**	**X*1**

X = predominant release pathway, **X** = additional release pathway, *1 Separately collected batteries containing mercury (or categorized under sorting as such) may be disposed of in specially secured landfills.

5.6. Measuring devices (for medical and household use)

Mercury has been widely used in medicine in instruments for measuring temperature and blood pressure such as thermometers and sphygmomanometers. Currently, this type of instrument is still being used, especially in developing countries.

There are two general types of **mercury thermometers** that measure body **temperature: Oral**/ rectal/baby **thermometers, containing** about 0.61 grams of **mercury**. Basal **temperature thermometers** (used to track slight changes in body **temperature), containing** about 2.25 grams of **mercury**. (EPA)

Table 8:
Measuring devices with mercury[5]

Type	Product	Example of products in which the products in the left column are used and assembled
Measuring devices for medical and household use)	Mercury thermometers 	Thermometers
	Mercury sphygmomanometers 	Sphygmomanometers

The mercury contained in these products can be released to the environment in the following way

Relevant life-cycle phases and expected release pathways[2]:

Life-cycle phase	Release pathway					
	Air	Water	Land	Products	General waste	Sector specific treatment/disposal
Production	X	X	X	X		X
Use	X	X	X			
Disposal	X		X		X	X

X = predominant release pathway, **X** = additional release pathway

5.7. Cosmetics and related Products

Mercury has been used in skin lightening creams, soaps, and as preservatives in some eye cosmetics. These products are rare or non-existent in some countries. The production and use has decreased significantly in the developed countries over the past decades. However, in other countries production and use continue.

Tabla 9:
Cosmetics with mercury

Type	Product	Example of products in which the products in the left column are used and assembled
Skin creams		Skin lightening creams and soaps

Mercury is used in cosmetics as a skin lightening agent and preservative. Cosmetics with mercury are often marketed as skin lightening creams and anti-aging treatments that remove age spots, freckles, blemishes and wrinkles. Adolescents sometimes use these products as acne treatments[7].

Manufacturers selling products that contain mercury often do not label their products appropriately. Companies that do so may use any of the following names: mercury, Hg, mercuric iodide, mercurous chloride, ammoniated mercury, amide chloride of mercury, quicksilver, cinnabaris (mercury sulfide), hydrargyri oxydum rubrum (mercury oxide), or mercury iodide. Directions to avoid contact with silver, gold, rubber, aluminum, and jewelry could also indicate the presence of mercury. Marketers of these products tend to target the Asian, African, Latino and Middle Eastern communities.

The FDA banned the use of mercury in most cosmetics at levels higher than 1 ppm in 1973. The agency has investigated skin lightening creams and also created an import alert for skin whitening creams containing mercury, which allows FDA agents to detain certain products at the border.

Tabla 10:
Skin care products with excessive mercury content (purchased in 2018)[8]

Country of purchase	Country of manufacture	Brand name	Mercury [ppm]
Indonesia	Not indicated	Collagen Plus Vit E Night Cream	7,111 [a]
Indonesia	Philippines	RDL Whitening Treatment Night Cream 8 Days Treatment	5,958 [a]
Indonesia	Malaysia	Temulawak Cream (Night Cream)	3,059 [a]
Indonesia	Not indicated	Natural 99 Vitamin E Plus	2,018 [a]
Philippines	Pakistan	Goree Beauty Cream	10,576 [a]
Philippines	China	Jiaoli Day Cream	1,693 [a]
Philippines	Hong Kong	Gemli Glutathione Grapeseed Extract (Day Cream)	1,565 [a]
Philippines	China	Jiaoli Night Cream	365 [a]
Bangladesh	Pakistan	Goree Beauty Cream with Lycopene	16,353 [a]
Bangladesh	Pakistan	Due Beauty Cream	11,940 [a]
Bangladesh	Taiwan	Huayenong - Bird's Nest Cosmetology	10,749 [a]
Bangladesh	Pakistan	Golden Pear l Beauty Cream	9,648 [a]
Bangladesh	Pakistan	Faiza Beauty Cream	9,053 [a]
Bangladesh	Taiwan	Egg White and Cherry 7 Days Specific Eliminating Freckle Whitening Cream	5,271 [a]
Bangladesh	Taiwan	Green Tea Whitening Anti -freckle Cream	5,068 [a]
Bangladesh	China,via Malaysia	Temulawak New Beauty White Cream (Night Cream)	1,884 [a]
Bangladesh	Pakistan	Hoor! Whitening Cream	1,083 [a]
Bangladesh	China	Jiaulihuic Hunsu Jioli Miraculous Day and Night Cream	711 [a]

Note: [a]Mercury content analyzed by Quality Assurance & Control Systems Laboratory (Greece) using Hydride Atomic Absorption Spectroscopy (HAAS)

Releases may occur during production, use and disposal of these products.

Relevant life-cycle phases and expected release pathways[2]:

Life-cycle phase	Release pathway					
	Air	Water	Land	Products	General waste	Sector specific treatment/disposal
Production	?	?		X	?	
Use		X				
Disposal					X	

X = predominant release pathway, **X** = additional release pathway

5.8. Pharmaceutical products

Mercury has been used in pharmaceutical products as a preservative to extend the life of these products. And in some cases mercury was used as a treatment for certain types of diseases.

Table 11:
Pharmaceutical products with mercury[5]

Type	Product	Example of products in which the products in the left column are used and assembled
Pharmaceutical products containing mercury (II) chloride	Pharmaceutical products including merbromin 	Products containing merbromin (adhesive plaster) Used as Merbromin solution

5.9. Biocides and pesticides

Many mercury compounds are toxic to microorganisms, and so these compounds have been used in biocides in paper industry and on seed grain and other agricultural applications. These uses have been discontinued or banned in many countries.

Relevant life-cycle phases and expected release pathways[2]:

Life-cycle phase	Release pathway					
	Air	Water	Land	Products	General waste	Sector specific treatment/disposal
Production	?	?	?	X	?	?
Use	X	X	X		X	X
Disposal		X	X		X	X

X = predominant release pathway, **X** = additional release pathway

5.10. Paints and varnishes

Phenyl mercuric acetate (PMA) and similar mercury compounds were formerly widely added as biocide to water based paints and may still be used in some countries. These compounds were used to extend shelf-life by controlling bacterial fermentation in the can (in-can preservatives) and to retard fungus attacks upon painted surfaces under damp conditions (fungicides).

The mercury contained in these products is released to the environment through the following routes:

Relevant life-cycle phases and expected release pathways[2]:

Life-cycle phase	Release pathway					
	Air	Water	Land	Products	General waste	Sector specific treatment/disposal
Production	X	X	X	X	X	X
Use	X	X			X	
Disposal					X	X

X = predominant release pathway, **X** = additional release pathway

5.11. Polyurethane with mercury catalysts

Polyurethane elastomer products are used for a wide range of end-products including rollers, flooring, gaskets, encapsulation of electronic components, shoe soles, shock absorption and repair of industrial installations. Without chemical analysis, it can be hard to distinguish mercury containing from mercury-free elastic polyurethane (also called PU or PUR), so importers and producers need to be asked, if more detailed estimates are desired.

Table 12:
Polyurethane with mercury catalysts[5]:

Type	Product	Example of products in which the products in the left column are used and assembled
Polyurethane elastomer products	Pharmaceutical products including merbromin 	Rollers, flooring, gaskets, encapsulation of electronic components, shoe soles, shock absorption and repair of industrial installations

The mercury contained in these products is released to the environment through the following routes:

Relevant life-cycle phases and expected release pathways[2]:

Life-cycle phase	Release pathway					
	Air	Water	Land	Products	General waste	Sector specific treatment/disposal
Production	**X**	**X**		**X**		**X**
Use	**X**	**X**				
Disposal	**X**		**X**		**X**	

X = predominant release pathway, **X** = additional release pathway

5.12. Laboratory chemicals and equipment

Mercury is used in laboratories in instruments, reagents, preservatives, and catalysts. Some of this mercury is released to air, primarily through lab vents. However, most of the mercury may be released in wastewater or disposed of as hazardous waste or municipal waste.

The total use of mercury for laboratory purposes is probably very low when compared with the quantity of other chemicals. Mercury may have been substituted in some of the equipment and for some of the mentioned analytical methods. Some standard analyses seem, however, difficult to substitute in practice – even though substitutes are in many cases available – because standards are there to improve reproducibility of the analysis practices and therefore favour the well-known, and they are often also required in public regulation.

Table 13:
Laboratory chemicals with mercury[5]:

Type	Product	Example of products in which the products in the left column are used and assembled
Laboratory reagents		Laboratory reagents to research and educational activities

The mercury contained in these products is released to the environment through the following routes:

Relevant life-cycle phases and expected release pathways[2]:

Life-cycle phase	Release pathway					
	Air	Water	Land	Products	General waste	Sector specific treatment/disposal
Use	**X**	**X**			**X**	**X**

X = predominant release pathway, **X** = additional release pathway

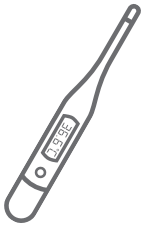
5.13. Other Products with mercury added

There is a wide variety of other products for industrial and domestic use that contain added mercury and that are still used today. A general detail of these products is given on the following page.

Table 14:
General products with mercury[5]

Type	Example of products in which the products in the left column are used and assembled
Mirrors for large telescopes	Equipment for astronomy
Rotary connectors	Production equipment, aeronautical lights
Mercury ion frequency standards**	Electronic measuring devices (signal generators and frequency meters)
Infrared detectors (those mercury, cadmium, and tellurium are mixed)	Electronic measuring devices including thermometers and densitometers, thermal image display devices, night vision devices, infrared spectrophotometers, Fourier transform infrared spectrophotometers
Gyrocompasses	Ships
Strain gauge sensors	Plethysmographs
Cumulative energizing time indicators	Medical devices
Radiation detectors	X-ray sensors
Mercury diffusion pumps	Vacuum chambers
Pressure relief devices	Pressure containers
Vermillion (pigment)	Vermillion inkpads
Jewerly	Gold and silver necklace, rings and earrings

** Mercury ion frequency standard is a stable oscillator whose frequency fluctuates very little and mainly used at standards organizations. Mercury and mercurous oxide are retained in sturdy vacuum containers and used less than 10mg for each oscillator.



6.- PRODUCTS WITHOUT MERCURY

Mercury-free products are more environmentally friendly and fulfill the same technical function as those products that do have added mercury. The use of mercury-free products eliminates the risk of exposure and the health effects of the people that mercury can cause.

Although in some cases it may happen that these products are slightly more expensive than those that do contain mercury. The reduction of environmental impacts and risks to the health of people should be an incentive to use this type of mercury-free products.

Table 15:
Examples of mercury free products

Product	Example
aneroid barometer	
aneroid sphygmomanometer	
MERCURY-FREE DENTAL FILLINGS	

Product	Example
digital thermometer	
digital barometer	
digital manometer	
LED Light Bulbs	
Lithium button-cell batteries	
cylindrical alkaline batteries	

7.- CASE STUDY 1: COMPARISON BETWEEN TWO BULB TYPES

The following table shows a comparison of two types of bulbs, one containing added mercury (CFL) and one that does not (LED)[9].

Table 16:
Examples of mercury free products

Specification	CFL	LED
Color	2700K, 5000K, and 6500K	
Wattage Range	15W to 200W equivalent	3W to 100W equivalent
Efficiency	Avg 40 lumens/watt; 2.5W CFL = 10W Incandescent	Avg 75 lumens/watt; 1.2W LED = 10W Incandescent
Bulb Life - based on 3 hours of use a day	Avg 7,500 - 10,000 hours	Avg 50,000 - 60,000 hours
Instant On	Optional, but still have a warm up	Yes
Dimmable	Most are not, newer bulbs tend to be dimmable but must read packaging	Yes
3-Way bulb option	Yes	No
Health and Safety	Bulbs can shatter and release mercury, emit more UV light which can fade or damage art and photographs	Most are plastic with limited risk of shattering, no mercury
Life Cycle Cost	Medium costs, lower energy usage and longer life	Lowest over lifetime due to lowest energy use and very long life
Availability	Widely available	More limited availability, but continuing to increase

LEDs:

Advantages

- ✓ Use much less power resulting in even lower electric bills and less pollution from power plants
- ✓ Very long life, 10X or more longer than CFLs
- ✓ Generate less heat than CFLs for less load on air conditioning systems, reduced danger of burns from touching bulbs, reduced fire hazard
- ✓ LEDs are typically RoHS compliant so there are no hazardous materials in the bulbs, minimal environmental impact and no risk of personal exposure to mercury.
- ✓ LED emit no Infrared or Ultraviolet light, so no risk of damage or degradation of artwork, photographs, or other sensitive items from exposure to the light.
- ✓ LEDs are instant on and not damaged by frequent power cycling.
- ✓ LEDs operate in freezing temperatures

Disadvantages

- X Initial cost. Though much cheaper over their total lifetime, the initial cost of the LED bulbs prevents most home owners from a full conversion at one time. They need to be swapped in as CFLs fail or replace hard to reach bulbs where their long life is an immediate benefit.
- X Less bulb style options, lower equivalent wattage, and no 3-way bulb options mean that certain applications like chandeliers or decorative globe bulb applications have no LED substitutes at this time.
- X LEDs are much more directional, which part of the reason they are so much more efficient, but true omnidirectional incandescent equivalents are just reaching the market and they are more expensive than the spot and flood bulb equivalents.
- X LEDs are sensitive to heat. Very hot locations do not allow the bulbs to cool properly and their life is shortened, though no exact data is available at this time to give clear upper temperature limits as it applies to residential applications.

CFLs:

Advantages

- ✓ Available in 3-way bulb configurations with 50W-100W-150W equivalents with a maximum consumption of 37W.
- ✓ Better in omnidirectional lighting applications like the incandescent bulbs they replace.
- ✓ CFLs in dimmable candelabra form are now available that are 40W equivalent outputs, finally making CFLs a viable option for chandeliers and other decorative lighting, though the aesthetics of the CFLs is still much lower than the incandescent bulb they replace.
- ✓ CFLs have more temperature or color range options and the warm white now closely matches the incandescent bulbs they replace. CFLs are also available in full spectrum output which is a benefit to individuals who suffer from Seasonal Affective Disorder.

Disadvantages

- X Mercury, all CFLs contain between 3mg and 5mg of this heavy metal which is a neurotoxin. It poses a high threat to the environment when failed bulbs are not recycled properly and it is an immediate, local danger when a CFL is broken.
- X While they last longer than incandescent bulbs, CFLs light output diminishes quickly over time and can be reduced by more than 50% over a year's time. By the time they fail, their output may only be 20% of the original rated output.
- X CFLs, have unpredictable failure modes. Most emit smoke or odors and there are numerous reports of CFLs catching on fire or exploding when failing. Many tend to pulse or strobe as they fail which can trigger headaches or seizures in those sensitive to rapid changes in lighting.
- X CFLs lifetimes are rated for very specific conditions. They are not intended to be cycled on and off more than a couple of times a day. The more a CFL is cycled on and off, the shorter its overall life will be.
- X Most CFLs will not even turn on in near freezing conditions and if they do, then the warm up time is much longer and their light output is greatly reduced.

If we take into consideration technical aspects (efficiency, durability, etc.) and aspects related to environmental risk and the health of people. The best option is to choose LED bulbs.

Chatacteristic	CFL	LED
Efficiency	✓	X
Long Life	✓	X
Environmental and Health risk	✓	X
Price	X	✓
Prevent mercury releases	✓	X

8.- INTERNATIONAL REGULATION ON MERCURY

8.1. Minamata Convention

In 2003, the Governing Council of UNEP decided that there was sufficient scientific evidence on the harmful consequences of mercury worldwide, which justified the adoption of measures to revert their effects at the global level. On January 19, 2013, 140 governments agreed on the text of this Multilateral Environmental Agreement whose objective is to protect human health and the environment from the adverse effects of anthropogenic emissions and releases of mercury and mercury compounds.

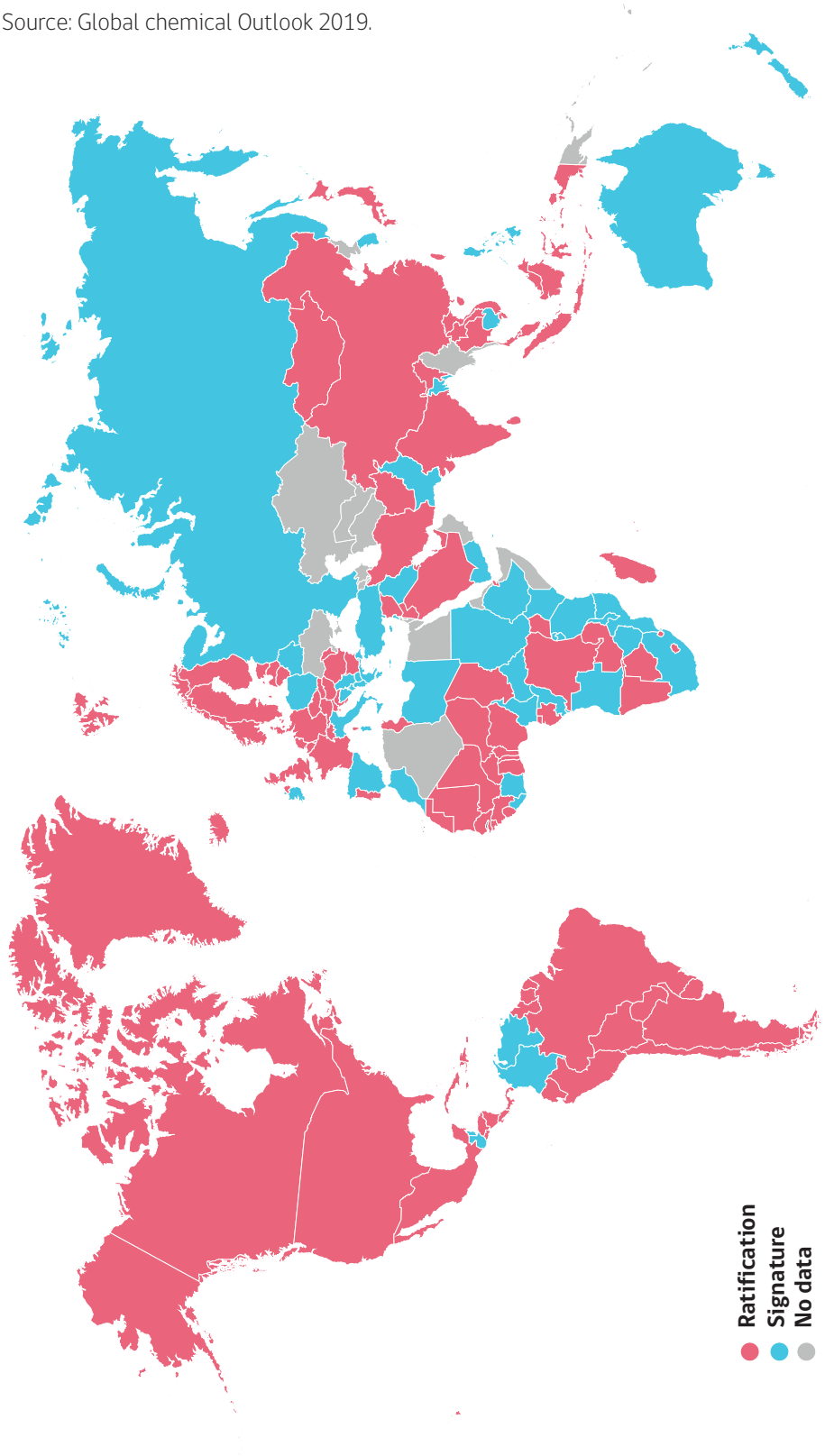
The Convention entered into force on August 16, 2017 and to date has been signed by 128 countries and ratified by 114 countries (as of september, 2019).

8.2. Matters regulated by the Minamata Convention

The Minamata Convention addresses all the aspects and activities associated with mercury that can generate impacts on the environment and human health. The highlights of the Convention include i) the prohibition of new mercury mines, ii) the phasing out of existing mines, iii) the reduction of the use of mercury in a series of products and processes (eg in ampoules, batteries, paints and cosmetics), iv) the promotion of measures to control emissions to the atmosphere and releases to water and soil (such as those produced by coal-fired thermoelectric plants), v) the environmentally sound interim storage of mercury as a commodity and its disposal once it becomes waste; vi) contaminated mercury sites; and vii) other sanitary issues.

Figure 10:
Parties to the Minamata Convention

Source: Global chemical Outlook 2019.



8.3. Products with added mercury

The Minamata Convention establishes in Article 4 that each party must take actions to not allow the manufacture, import and export of products with added mercury that are listed in Part I of Annex A of the agreement. Below are the products with added mercury that are regulated by the agreement.

Table 17:
Products subject to Article 4, paragraph 1[11]

Mercury-added products	Date after which the manufacture, import or export of the product shall not be allowed (phase-out date)
Batteries, except for button zinc silver oxide batteries with a mercury content < 2% and button zinc air batteries with a mercury content < 2%	2020
Switches and relays, except very high accuracy capacitance and loss measurement bridges and high frequency radio frequency switches and relays in monitoring and control instruments with a maximum mercury content of 20 mg per bridge, switch or relay	2020
Compact fluorescent lamps (CFLs) for general lighting purposes that are ≤ 30 watts with a mercury content exceeding 5 mg per lamp burner	2020
Linear fluorescent lamps (LFLs) for general lighting purposes: (a) Triband phosphor < 60 watts with a mercury content exceeding 5 mg per lamp; (b) Halophosphate phosphor ≤ 40 watts with a mercury content exceeding 10 mg per lamp	2020
High pressure mercury vapour lamps (HPMV) for general lighting purposes	2020
Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for electronic displays: (a) short length (≤ 500 mm) with mercury content exceeding 3.5 mg per lamp (b) medium length (> 500 mm and ≤ 1 500 mm) with mercury content exceeding 5 mg per lamp (c) long length (> 1 500 mm) with mercury content exceeding 13 mg per lamp	2020
Cosmetics (with mercury content above 1ppm), including skin lightening soaps and creams, and not including eye area cosmetics where mercury is used as a preservative and no effective and safe substitute preservatives are available1/	2020
Pesticides, biocides and topical antiseptics	2020
The following non-electronic measuring devices except non-electronic measuring devices installed in large-scale equipment or those used for high precision measurement, where no suitable mercury-free alternative is available: A. barometers; B. hygrometers; C. manometers; D. thermometers; E. sphygmomanometers	2020

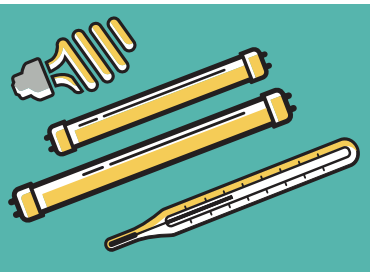
In the case of dental amalgams, its use has not been prohibited. However, the Minamata Agreement establishes a series of provisions that countries must take. On Table 18 these are detailed.

Table 18:
Products subject to Article 4, paragraph 3[11]

Mercury-added products	Provisions
Dental amalgam	Measures to be taken by a Party to phase down the use of dental amalgam shall take into account the Party's domestic circumstances and relevant international guidance and shall include two or more of the measures from the following list: (i) Setting national objectives aiming at dental caries prevention and health promotion, thereby minimizing the need for dental restoration; (ii) Setting national objectives aiming at minimizing its use; (iii) Promoting the use of cost-effective and clinically effective mercury-free alternatives for dental restoration; (iv) Promoting research and development of quality mercury-free materials for dental restoration; (v) Encouraging representative professional organizations and dental schools to educate and train dental professionals and students on the use of mercury-free dental restoration alternatives and on promoting best management practices; (vi) Discouraging insurance policies and programmes that favour dental amalgam use over mercury-free dental restoration; (vii) Encouraging insurance policies and programmes that favour the use of quality alternatives to dental amalgam for dental restoration; (viii) Restricting the use of dental amalgam to its encapsulated form; (ix) Promoting the use of best environmental practices in dental facilities to reduce releases of mercury and mercury compounds to water and land.

Figure 11: Mercury in products[4]

By **2020**, it is expected that the global trade, manufacture, and use of certain mercury added-products will be phased out through the Minamata Convention on Mercury. In addition, there is a need for safe disposal of mercury-containing waste beyond 2020.



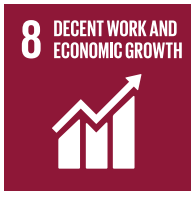
Mercury-free alternatives are already widespread and available on the global market

9.– THE SUSTAINABLE DEVELOPMENT GOALS (SDGs) AND THE MINAMATA CONVENTION ON MERCURY

The Minamata Convention on Mercury is closely related to the Sustainable Development Goals, since several objectives of the agreement contribute to the fulfillment of the following SDGs.

Table 19:
Linkage between the Minamata Convention of mercury and the SDGs[12]

Number of SDG	Relationship between Minamata Convention and SDG
	SDG Goal 1: End poverty in all its forms everywhere The urban and rural poor routinely face unacceptably high risks of exposure to mercury because of their occupations (e.g. mercury mining, artisanal and small-scale gold mining, waste management, recycling), living conditions (proximity to dumpsites and incinerators) and lack of knowledge of potential health impacts of exposure to mercury. At the same time, ecosystems that provide essential resources for the survival of the rural poor, are affected by mercury contamination. UNDP-supported interventions assist partners in introducing alternatives, best practices and techniques to minimize the use and release of mercury, and also address the underlying socio-economic challenges that are at the core of existing practices that use mercury.
	SDG Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture One of the main sources for exposure to mercury is through consumption of mercury contaminated fish and shellfish. The consumption of fish containing high levels of mercury, in particular those high on the food chain as mercury bioaccumulates, can have serious health consequences (see SDG 3). This causes health concerns, in particular for pregnant women, the child in utero and young children, as well as for poor communities relying on subsistence fishing. UNDP helps countries decrease the use of mercury and its release into the environment from various sectors, indirectly halting and reducing the build-up of mercury in the food chain.
	SDG Goal 3: Ensure healthy lives and promote well-being for all at all ages Mercury is toxic to human health, posing a particular threat to the development of the child in utero and early in life. Human exposure occurs mainly by inhaling elemental mercury vapors during industrial processes and by consuming contaminated fish and shellfish, and can lead to mercury poisoning. Mercury exists in various forms: elemental; inorganic; and organic, which all have different toxic effects, including on the nervous, digestive and immune systems, and on lungs, kidneys, skin and eyes. UNDP supports governments, the private sector and other partners, to reduce or preferably phase-out the use of mercury and mercury-containing products, and minimize its releases, to ultimately protect human and environmental health.

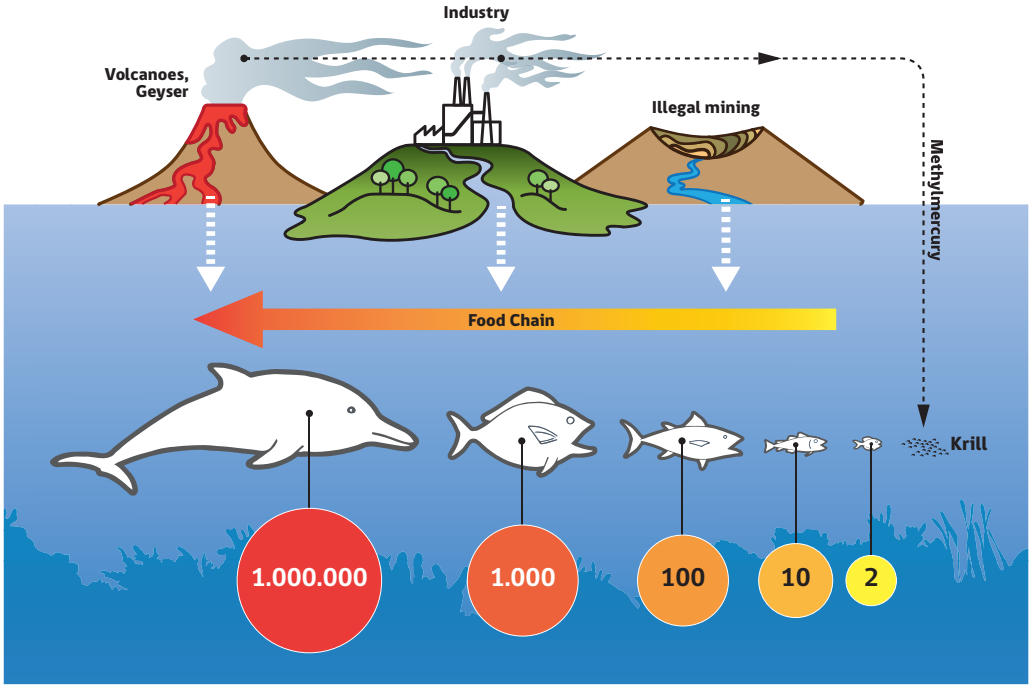
Number of SDG	Relationship between Minamata Convention and SDG
	SDG Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all. Coal burning, and to a lesser extent the use of other fossil fuels to generate energy, is the second most significant anthropogenic source of mercury emissions into the atmosphere. Use of air pollution controls and more stringent regulations, combined with improved combustion efficiency, can offset most of the mercury releases associated with the increase in coal use, particularly in Asia and South America. However, reductions in current mercury releases will only be achieved after a shift to cleaner and more sustainable energy sources and the introduction of more efficient technologies and products (e.g. mercury-free energy-efficient lighting). UNDP supports countries in strengthening their regulatory frameworks, revising outdated industrial processes and technologies to reduce releases and
	SDG Goal 8: Decent work and economic growth Exposure to mercury can occur through the inhalation of mercury vapors. Such exposure is most likely to happen in the workplace. Among the most dangerous professions and livelihoods in terms of mercury exposure are artisanal and small-scale gold mining, waste handling and recycling, mercury refining, and health and dental care. Phasing-out the production and use of products and processes which use mercury is the main way to reduce worker exposure. UNDP assist governments and various sectors introduce mercury-free products and processes, while also supporting the development of workplace safety standards and procedures, introducing personal protective measures, and addressing the underlying socio-economic causes that lead to the use of mercury and products containing mercury.
	SDG Goal 12: Ensure sustainable consumption and production patterns Sustainable consumption and production aims at "doing more with less," increasing net welfare gains from economic activities by reducing resource use, degradation and pollution, while increasing the quality of life. An important aspect of our work is the reduction of mercury pollution and mercury-containing wastes by introducing alternative products, processes and technologies that are mercury-free, cost-effective and in line with best available technology guidelines. Such interventions are aligned with those that increase resource efficiency, use clean and renewable energy, and reduce waste generation, all of which have important mercury reduction co-benefits
	SDG Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development Over three billion people depend on marine and coastal biodiversity for their livelihoods, which are being threatened by marine pollution reaching alarming levels. Mercury levels in certain types of fish (e.g. bluefin tuna, swordfish) have become so high that some Governments advise against consumption or have introduced import bans. UNDP helps countries decrease the use and release of mercury from various land-based activities, prevent mercury from entering water sources, and reduce the build-up of mercury in the food chain.

10.– MERCURY IMPACTS ON ENVIRONMENT

Due to its physical and chemical properties, mercury is a pollutant that has the capacity to transport through long distances in the atmosphere and once it is released to the environment it does not disappear, but it is transformed into other chemical species such as methylmercury. Therefore, mercury is considered a global pollutant since it can be found on all continents.

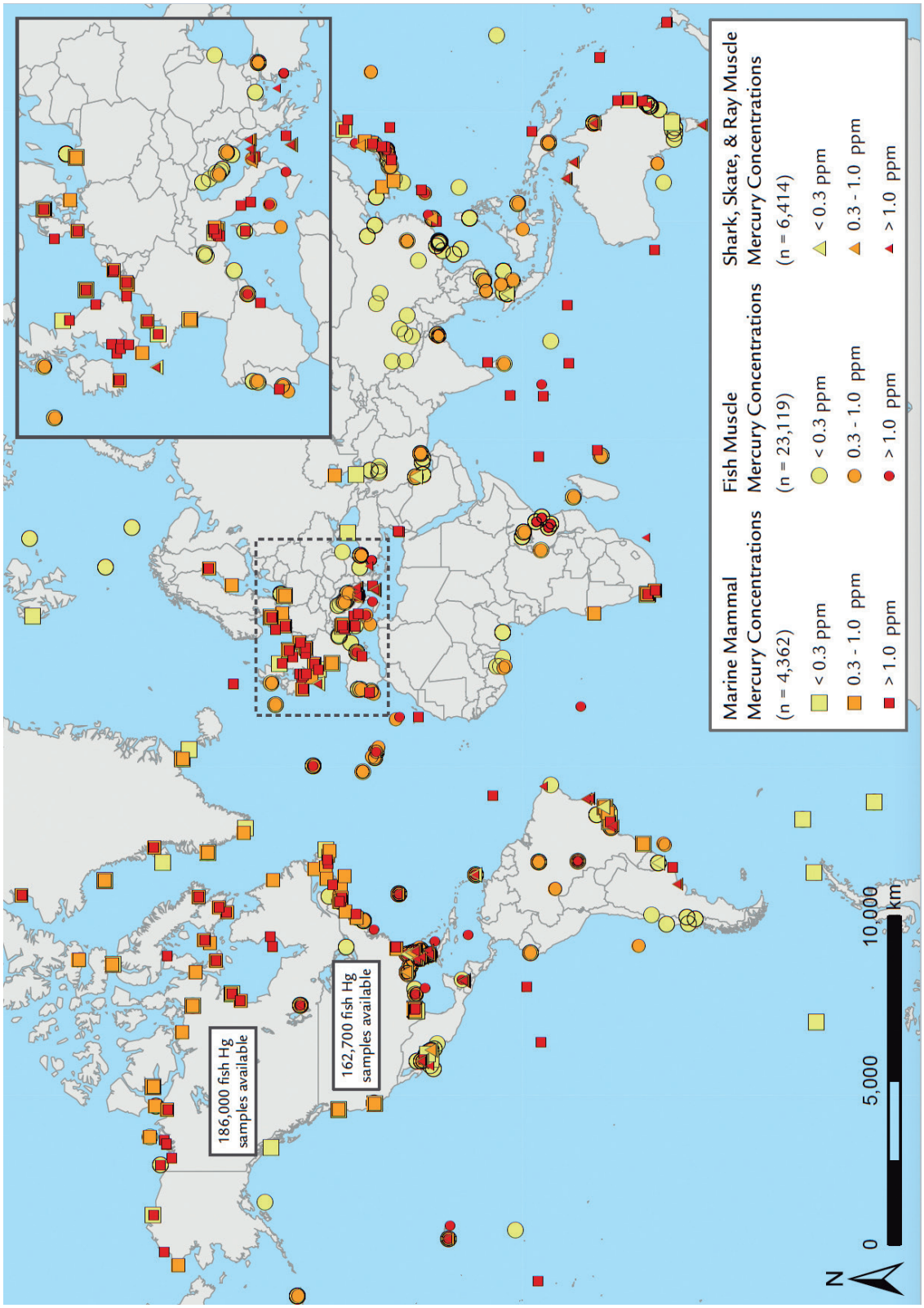
Mercury also has the ability to bioaccumulates and biomagnifies through the food chain, these characteristics added to the high toxicity of this metal, causing mercury to generate negative effects on people's health and the environment at relatively low doses.

Figura 12:
Bioaccumulation and biomagnification of mercury



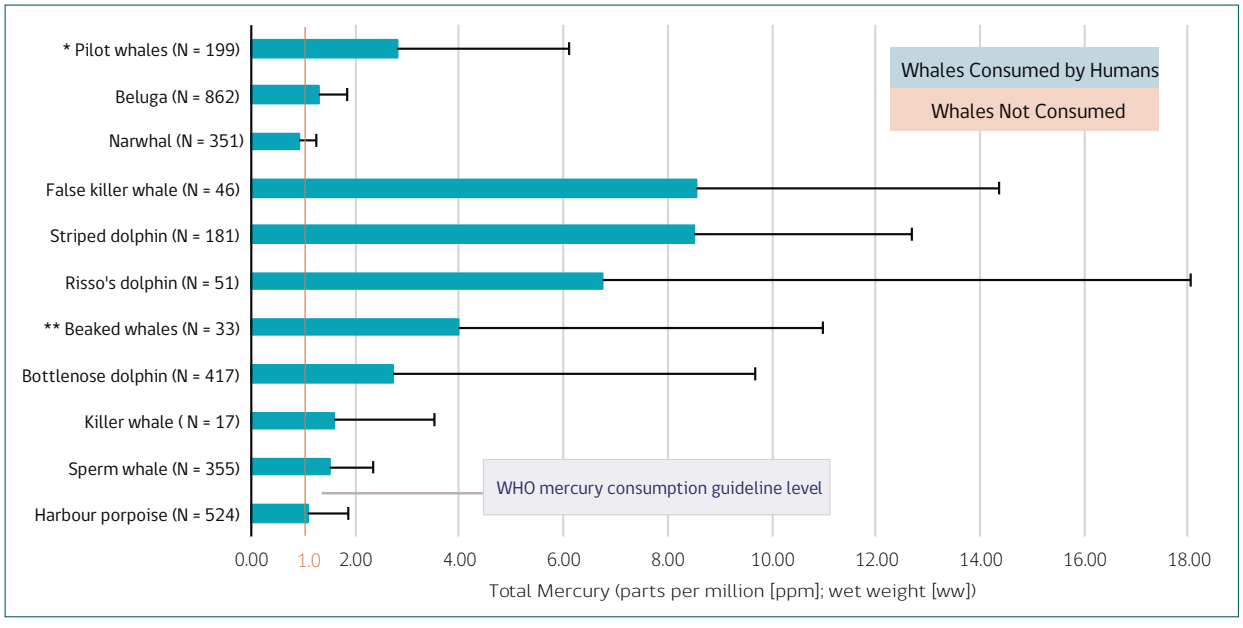
The following picture shows the global distribution of mercury in fish and marine mammals.

Figure 13:
The global distribution of fish, including shark, and marine mammal mercury concentrations[14]



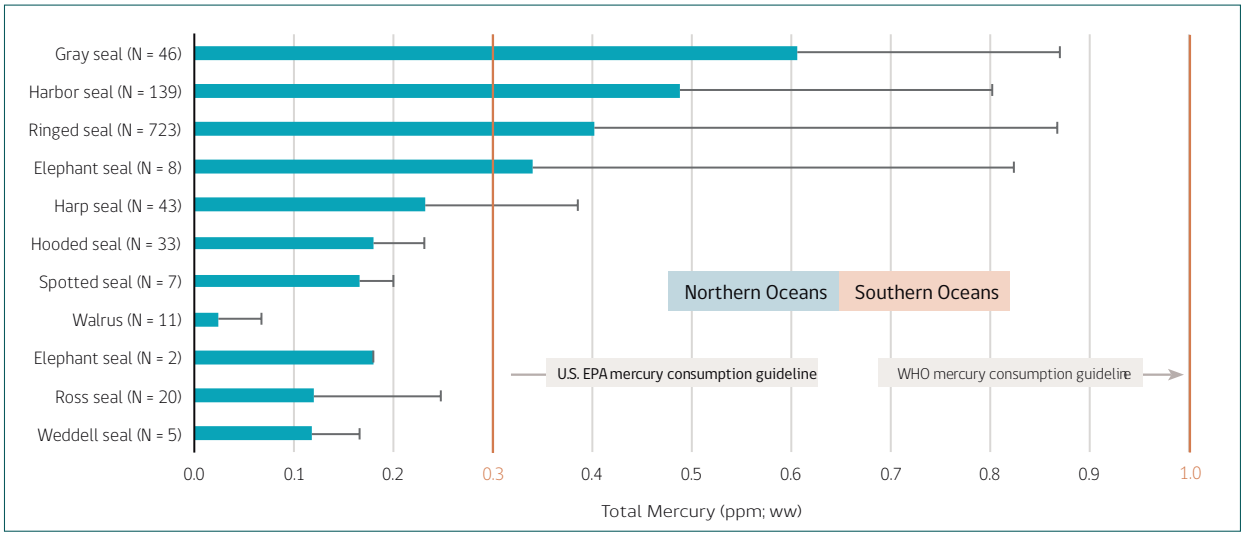
In addition, high levels of mercury have been reported in species such as seals, walruses and whales (bri, 2016). In the following images you can see the total mercury concentration measured in various marine species.

Figure 14:
Total Mercury Concentrations (Average +/- S.D.) of muscle tissue from Toothed Whales[15]



*Data represent the weighted mean from two species of pilot whale, the long-finned (Globicephala melas) and the short-finned (G. macrorhynchus).
**Data represent the weighted mean of samples from several species of beaked whale, Family Ziphiidae.

Figure 15:
Total Mercury Concentration (Average +/- S.D.) in Muscle Tissue in Seals and Walruses (Pinnipeds)[15]



Mercury can cause effects in the reproductive system of fish, generating negative effects on the growth of its populations. In addition, birds and mammals that eat contaminated fish with mercury are more exposure to methylmercury than other animals in water ecosystems. Predators that eat these birds and mammals are also at risk. At high levels of exposure, methylmercury's harmful effects on these animals include[13]:

- death,
- reduced reproduction,
- slower growth and development, and
- abnormal behavior.

10.1. This section will be complemented and expanded, to better explain that only the ASGM where mercury is used can generate sites contaminated with this metal.

In soils contaminated with mercury it is possible to find this metal in its inorganic form ($HgCl_2$, $Hg(OH)_2$, HgS and HgO). It is also possible to find it in organic forms such as Methylmercury.

These mercury species are complex with organic matter and clays present in the soil. This fact limits the mobility of mercury in the soil, which causes the presence of large reservoirs of mercury of anthropogenic origin, a significant source of this pollutant.

Soils contaminated with mercury can generate contamination risks for rivers, groundwater, etc. It also generates health risks for people who live in sectors where there is contamination, since people can be exposed to dust with mercury and food contaminated with this metal.

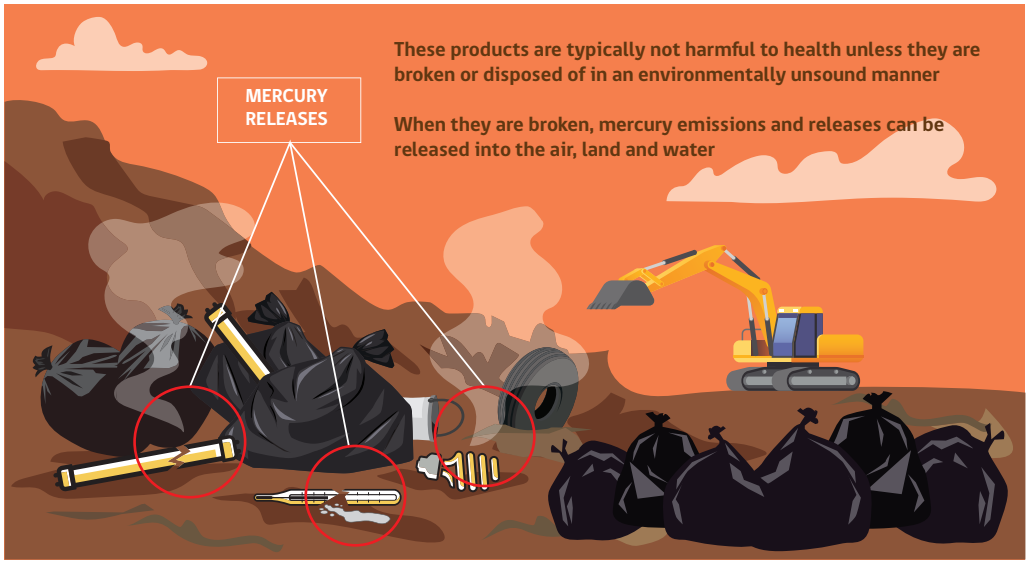
Figure 16:
Mercury contaminated area adjacent to the Honda River in Colombia from an artisanal gold mine[16]

Image: video still from france 24's spanish channel.

Artisanal and small-scale gold mining (ASGM), is an important source for the generation of soils contaminated with mercury. Since this activity uses mercury to amalgamate gold, however, the processes are not carried out with the appropriate safety measures, so that a significant fraction of mercury produced in these processes is released to the soils and water sources where develops this type of mining.

Figure 17:
Elemental mercury used in ASGM

Figure 18:
Mercury releases into the environment[4]



11.- MERCURY IMPACTS ON HEALTH

Mercury is highly toxic and can cause adverse effects on human health. However, the toxic effects of mercury depend on its chemical form and the route of exposure (USGS). Mercury exposure at high levels can harm the brain, heart, kidneys, lungs, and immune system of people of all ages. High levels of methylmercury in the bloodstream of unborn babies and young children may harm the developing nervous system. In addition, Mercury can cause adverse effects in the nervous system, affecting neurological, cognitive, and motor functions[13]..

Among the factors that determine eventual effects on health, as well as their severity, are the following:

- The form of mercury in question;
- The dose;
- The age or stage of development of the exposed person (the fetal stage is the most vulnerable);
- The duration of the exposure;
- The route of exposure (inhalation, ingestion or skin contact).

There are some populations that are especially susceptible to the adverse effects of mercury, most notably fetuses and young children. Mercury absorbed in the body of a pregnant woman can also have effects in the fetus (WHO).

The most emblematic case on the relationship between mercury and health effects is Minamata Disease, which corresponds to a neurotoxic disorder caused by the intake of marine products contaminated with methylmercury compounds.

The main symptoms of this disease include ataxia, hearing disorders, visual disorders and sensory disorders. We must also consider that if a pregnant woman is exposed to high concentrations of methylmercury, it is highly probable that the fetus may suffer from Minamata disease.

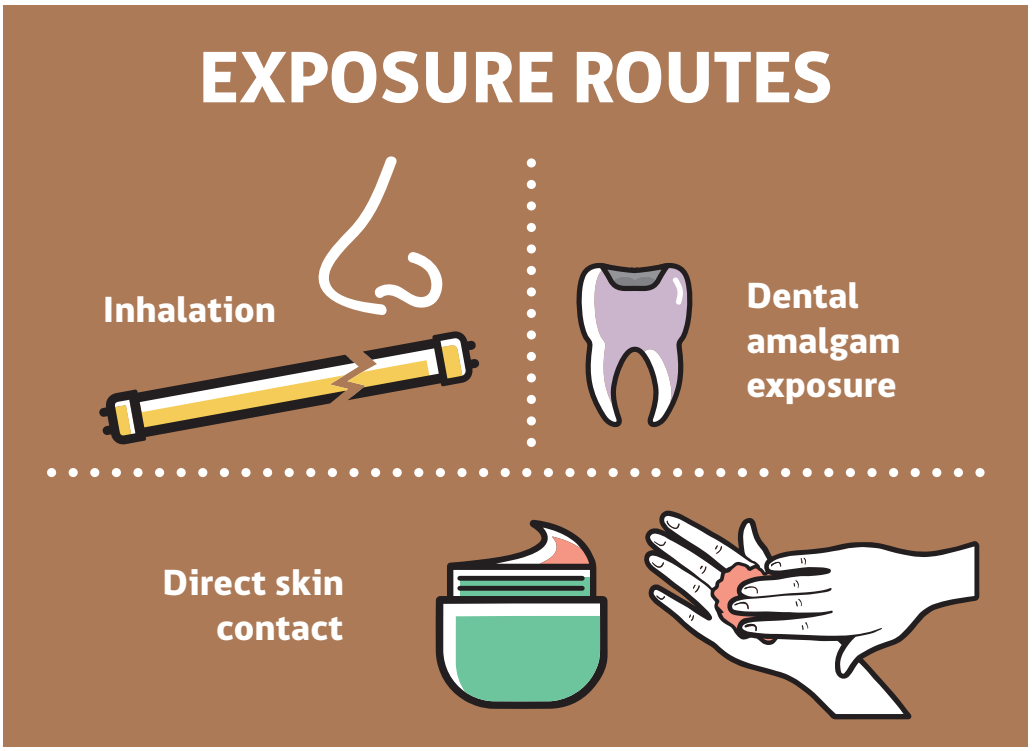
11.1. How People are exposed to Mercury?

In general, most of the population is exposed to low levels of mercury that exists in various forms such as Methylmercury, Elemental (metallic) mercury and other mercury compounds. The most common ways people are exposed to mercury are[17]:

- Inhalation
- Direct contact with the skin
- Ingestion of contaminated food and water

Other exposures may result from using or breaking products containing mercury such as bulbs, thermometers, cosmetics, etc.

Figure 19:
Mercury exposure routes[4]



11.1.1. Exposures to Methylmercury

Methylmercury, a highly toxic organic compound, is the form of mercury found most frequently in people. Almost all people in the world have at least trace amounts of methylmercury in their bodies, reflecting its prevalence in the environment. However, most people have mercury levels in their bodies below the level associated with possible health effects. For instance, nearly all methylmercury exposures in the U.S. occur through eating fish and shellfish that contain higher levels of methylmercury.

11.1.2. Exposures to Elemental (Metallic) Mercury

The most common exposure to metallic mercury occurs when mercury is released from a mercury added product or device that breaks (.If the mercury is not immediately contained or cleaned up, it can evaporate, becoming an invisible, odorless, toxic vapor. Exposures may occur when people breathe this vapor and inhale it into their lungs. Poorly ventilated, warm, indoor spaces are of particular concern in cases of airborne mercury vapors.

Note that where metallic mercury generally is contained in glass or metal, it does not pose a risk unless the product is damaged or broken and mercury vapors are released.

The main sources of common potential exposure to metallic mercury are described below.

- **Fever thermometers:** It is common for children to break fever thermometers in their mouths. When a thermometer containing mercury breaks in a child's mouth and the child might have swallowed some mercury, the mercury poses a low risk in comparison to breathing mercury vapor.
- **Cosmetics with mercury:** skin lighteners and anti-aging products for the skin, they have high amounts of mercury. This mercury is absorbed through the skin.
- **Novelty jewelry:** Some necklaces contain a glass pendant that contains mercury. The mercury-containing pendants can come in various shapes such as hearts, bottles, balls, saber teeth, and chili peppers. If broken, they can release metallic mercury to the environment.
- **Other consumer products:** Metallic mercury is often found in school laboratories. It is also in some thermometers, barometers, switches, thermostats, and electrical switches.
- **Dental fillings:** Mercury is used in dentistry in dental amalgam, also known as "silver filling". Dental amalgam is a direct filling material used in restoring teeth. It is made up of approximately 40-50% mercury, 25% silver, and 25-35% blend of copper, zinc and tin. Amalgam use is declining because the incidence of dental decay is decreasing, and because well-performing substitute materials are available for restoring teeth
- **ASGM:** Mercury is mixed with gold-containing materials, forming a mercury-gold amalgam. The amalgam is then heated, vaporizing the mercury and leaving the gold. This process is very dangerous and can lead to significant mercury exposure. Miners working tailings in areas where mercury was previously used can also be inadvertently exposed to the residual mercury in these deposits.

11.1.3. Exposures to Other Mercury Compounds

Other compounds of mercury, like phenylmercury acetate and ethylmercury, have been commonly used as fungicides, preservatives, antiseptics (e.g., Mercurochrome, a trade name of the antiseptic merbromin) or disinfectants. They have also been used in a variety of products. Most uses have been discontinued.

12.- HOW TO DISPOSE OF PRODUCTS THAT CONTAIN MERCURY[18]

First, the best action we can take when this is possible is to buy or use products without added mercury. However, if in our home or place of work there are products with added mercury such as batteries, thermometers, manometers, etc. and we need to disposal them, the best alternative is to avoid having these products in regular household trash and find a place where we can disposal these products to be recycled.

Recycling mercury-containing products is one of the best ways to help prevent mercury releases to the environment by keeping these products out of landfills and incinerators. Because, once landfilled, mercury from the products may end up in groundwater, and potentially in sources of drinking water.

Figure 20:
Safe disposal of mercury products

13.- CASE STUDY 2: WHAT TO DO WHEN A MERCURY-CONTAINING PRODUCT BREAKS[19],[20].

What NEVER to do after a mercury spill

- X Never use a vacuum cleaner to clean up mercury. The vacuum will put mercury into the air and increase exposure.
- X Never use a broom to clean up mercury. It will break the mercury into smaller droplets and spread them.
- X Never pour mercury down a drain. It may lodge in the plumbing and cause future problems during plumbing repairs. If discharged, it can cause pollution of the septic tank or sewage treatment plant.
- X Never walk around if your shoes might be contaminated with mercury. Contaminated clothing can also spread mercury around.

What to do

- ✓ Have everyone else leave the area; don't let anyone walk through the mercury on their way out. Make sure all pets are removed from the area. Open all windows and doors to the outside; shut all doors to other parts of the house.
- ✓ DO NOT allow children to help you clean up the spill.
- ✓ Mercury can be cleaned up easily from the following surfaces: wood, linoleum, tile and any similarly smooth surfaces.
- ✓ If a spill occurs on carpet, curtains, upholstery or other absorbent surfaces, these contaminated items should be thrown away in accordance with the disposal means outlined below. Only cut and remove the affected portion of the contaminated carpet for disposal.

Figure 21: What to do when a mercury-containing product breaks

WHAT NEVER TO DO

Never pour mercury down a drain

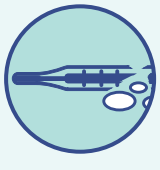
Never use a vacuum cleaner to clean up mercury

Never walk around if your shoes might be contaminated with mercury

What you should do

DO NOT allow children to help you clean up the spill.

Open all windows and doors to the outside; shut all doors to other parts of the house.



Pick up any broken pieces of glass and place them on a paper towel. Fold the paper towel, place it in a zipper-top bag, and seal the bag.

Clean up the beads of mercury. Use a squeegee or cardboard to slowly roll the beads onto a sheet of paper. Put the paper towel, paper, eye dropper, or anything else that has mercury on it, into a zipper-top bag, and seal the bag.

In order to obtain more detailed information about the actions to be taken if a mercury products breaks, we recommend to visit the procedures developed and recommended by the EPA.

1. What to Do if a mercury thermometer breaks
https://www.epa.gov/mercury/what-do-if-mercury-thermometer-breaks)

2. What to Do if a CFL or other fluorescent bulb breaks
(https://www.epa.gov/cfl/cleaning-broken-cfl)

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ABBREVIATIONS AND ACRONYMS

CFLs : Compact Fluorescent Lamps
CCFL : Cold Cathode Fluorescent Lamps
EEFL : External Electrode Fluorescent Lamps
EPA : Environmental Protection Agency
FDA : Food and Drugs Agency
LED : Light-emitting diode
LFLs : Linear Fluorescent Lamps
PPM : Parts per million
SDGs : Sustainable Development Goals
UN : United Nations
UNDP : United Nations Development Programme
USGS : United States Geological Service
UV : Ultra Violet Light
W : Watts
W/W : Weight of solute/ weight of solvent
WHO : World Health Organization

Ministerio del Medio Ambiente

Gobierno de Chile