AN NGO INTRODUCTION TO MERCURY POLLUTION AND THE MINAMATA CONVENTION ON MERCURY

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May 2014

IPEN
a toxics-free future

IPEN is a leading global organization working to establish and implement safe chemicals policies and practices that protect human health and the environment around the world. IPEN's mission is a toxics-free future for all.

IPEN's global network is comprised of more than 700 public-interest non-governmental organizations in 116 countries. Working in the international policy arena and in developing countries, with international offices in the US and in Sweden, IPEN is coordinated via eight IPEN Regional Offices in Africa, Asia & the Pacific, Central/Eastern Europe, Latin America & the Caribbean, and the Middle East.

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IPEN's Mercury-Free Program

IPEN launched its Mercury-Free Campaign in 2010 to address the alarming level of human and environmental health threats posed by mercury around the world. From 2010-2013 the Mercury-Free Campaign focused on: building capacity, educating and orienting NGOs on issues related to mercury pollution; and engaging and promoting NGO participation in the mercury treaty process to promoting the development of a strong mercury treaty.

In January 2013, governments from 140 countries agreed on final text for a global treaty on mercury – the first global treaty on the environment in well over a decade. The Treaty was then adopted in October 2013, and named the Minamata Convention. This Treaty reflects a global consensus that mercury poses a serious threat to human health and the environment, and applies pressure to eliminate mercury use from the global economy.

With the Treaty in place, IPEN's Mercury-Free Program focuses on:

- building capacity, educating and orienting NGOs on issues related to mercury pollution and the Minamata Convention; and
- advancing on-the-ground efforts to implement the Convention and reduce global and local mercury pollution.

***Cover Photo Credits:** Image of African woman and child panning for gold by Larry C. Price/ Pulitzer Center on Crisis Reporting 2013.*

CONTENTS

LIST OF ACRONYMS

AAP	American Academy of Pediatrics
ALMR	Association of Lamp and Mercury Recyclers
AMDE	Atmospheric Mercury Depletion Event
APCD	Air Pollution Control Device
ASGM	Artisanal and Small-Scale Gold Mining
BAT	Best Available Techniques
BPOM	Indonesian Food and Drug Control Agency
CDC	United States Centers for Disease Control and Prevention
CFL	Compact Fluorescent Lamp
COP	Conference of Parties
CSO	Civil Society Organization
EMEA	European Agency for the Evaluation of Medicinal Products
EPA	United States Environmental Protection Agency
EPR	Extended Producer Responsibility
FAO	United Nations Food Agriculture Organization
FDA	United States Food and Drug Administration
FGD	Flue Gas Desulfurization Systems
GAIA	Global Alliance for Incinerator Alternatives
GC	UNEP Governing Council
GEM	Gaseous Elemental Mercury
HCWH	Health Care Without Harm
HID	High-Intensity Discharge Lamp
IARC	International Agency for Research on Cancer
IPEN	International POPs Elimination Network
LCD	Liquid Crystal Displays
LED	Light-Emitting Diode
LNG	Liquid Natural Gas
MSDS	Material Safety Data Sheet
NGO	Non-governmental Organization
PAN	Pesticide Action Network
POP	Persistent Organic Pollutant
PTWI	Provisional Tolerable Weekly Intake
PVC	Polyvinyl Chloride
RGM	Reactive Gaseous Mercury
RoHS	Restrictions in the use of Hazardous Substances
S/S	Solidification/Stabilization
SCR	Selective Catalytic Reduction
TGM	Total Gaseous Mercury

1. FOREWORD

This booklet provides information about the toxic environmental pollutant mercury and its harm to human health and the environment and the recently adopted Minamata Convention on Mercury (also referred to as the mercury treaty or the treaty).

The first edition of this NGO Introduction to Mercury Pollution, originally released in October 2010, was written to help educate non-governmental organizations (NGOs) and others engaged in the global mercury treaty negotiations that led to the Minamata Convention.

This updated and revised edition has been produced to further encourage and enable global civil society organizations to engage in local, national and international activities aimed at controlling mercury pollution. It includes information they can use in programs and campaigns aimed at raising mercury awareness among their constituents and among the public at large. It identifies sources of mercury pollution, the articles of the mercury treaty that relate to those mercury sources and suggests what can be done to control those sources. The booklet also summarizes the most important aspects of the Minamata Convention and it encourages organizations of civil society in all countries to engage in advocacy efforts aimed at ensuring that governments adopt, ratify and fully implement the mercury treaty. It also includes additional suggestions on how different aspects of the mercury treaty may be used in campaigns by NGOs and civil society organizations (CSOs) to encourage government action to minimise mercury pollution.

The booklet's intended audience is leaders and members of those NGOs and CSOs for whom the protection of public health and the environment from harm caused by mercury pollution is—or should be—a topic of concern. These include public health and environmental advocacy organizations, organizations of medical and health care professionals, organizations representing communities or constituencies potentially impacted by mercury exposure, trade unions and others.

This booklet has been prepared and updated by the International POPs Elimination Network (IPEN). IPEN is a global network of more than 700 public interest, non-governmental health and environmental organizations working in more than 100 countries. The network was originally founded to promote the negotiation of a global treaty to protect human health and the environment from a class of toxic chemicals called persistent organic pollutants (POPs). Following adoption by governments of the Stockholm Convention on POPs, IPEN expanded its mission beyond POPs and now supports local, national, regional and international efforts

to protect human health and the environment from harms caused by exposure to all kinds of toxic chemicals.

We would like to thank Sweden's Environmental Protection Agency and Switzerland's Federal Office for the Environment and other IPEN donors for providing financial support that made the production of this booklet possible. The views expressed, however, do not necessarily reflect those of IPEN's donors.

We also thank those who have taken time to provide information for this updated booklet or to review it in part or in whole. Special thanks go to Joe DiGangi, Yuyun Ismawati, Valerie Denney, Jindrich Petrlik, Gilbert Kuepouo, Manny Calonzo and Bjorn Beeler as well as all the others who participated in the first edition of this booklet. Any and all mistakes in this booklet, however, are solely the responsibility of its authors.

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April 2014

2. THE MINAMATA CONVENTION ON MERCURY

The body of scientific knowledge about the harms to human health and the environment caused by mercury exposure has grown over the years and many governments have already taken some steps to control—within their jurisdictions—industrial and other human activities that release mercury into the environment. However, because mercury is a global pollutant, no national government acting alone can protect its people and its environment from the harms caused by mercury pollution.

Recognizing this, governments agreed in 2009 to start intergovernmental treaty negotiations with the aim of preparing a global, legally binding mercury-control treaty. The first meeting of the Intergovernmental Negotiating Committee to Prepare a Global Legally Binding Instrument on Mercury took place in Stockholm, Sweden, in June 2010. The negotiations were completed three years later and the Minamata Convention on Mercury was adopted in October 2013 at a diplomatic conference in Kumamoto, Japan.

The objective of the Minamata Convention on Mercury is "*to protect the human health and the environment from anthropogenic releases of mercury and mercury compounds*" (Article 1).

The new treaty is an important step forward in the control of mercury pollution worldwide and represents a global consensus that mercury pollution is a serious threat to human health and the environment, and that action is needed to minimize and eliminate mercury emissions and releases in order to reduce that threat. The treaty also progresses the ambit of international chemical conventions in that it specifically provides for and highlights the need to protect human health – a provision that is often absent in other chemical treaties. Significantly, this treaty includes a specific article related to human health (Article 16) with measures and activities that can be undertaken to assess and protect human health from mercury. In addition it outlines an important requirement that information related to mercury and human health *must not be kept confidential* thereby underscoring the public Right To Know about mercury impacts on their health.

Overall, the mercury treaty seeks to reduce mercury supply and trade, phase-out or phase-down certain products and processes that use mercury and control mercury emissions and releases. The use of mercury in Artisanal and Small-Scale Gold Mining (ASGM) has been recognized as one of the largest sources of atmospheric mercury pollution in the world today and the mercury treaty includes provisions to assess and minimize the use of mercury in ASGM. Emissions and releases of mercury pollution from the fossil fuel sector form an additional major anthropogenic mercury source and are addressed through a range of provisions aimed at significant reductions. The treaty also addresses the contribution to global mercury pollution from wastes, including mining, industrial processes and mercury-added products in their disposal phase such as landfills and incineration.

The treaty recognizes the full life-cycle impacts of mercury related products and processes in part by specific articles on supply and trade, use in products and processes, mercury waste, contaminated sites and environmentally sound mercury disposal. While many products and processes are subject to phase-out or phase-down some allowed uses may continue (such as ASGM) and for these specific trade authorizations an environmentally sound interim storage will be required.

Many of the treaty's articles contain a mixture of obligatory and voluntary measures. Nevertheless, many of these provisions may be used to positive effect by governments, NGOs and others that wish to undertake mercury minimization and reduction efforts.

Financial and technical support from the dedicated financial mechanism is likely to be prioritized to obligatory measures. Actions under these articles and the voluntary components of other articles may or may not qualify for financial assistance.

IPEN is committed to make use of treaty provisions in projects and campaigns in the countries where we are active. IPEN also plans to actively participate in treaty Conferences of the Parties and Expert Groups with efforts to strengthen the effectiveness of the treaty where this can be done.

Articles of the Minamata Convention on Mercury

This booklet addresses the individual Articles of the Minamata Convention on Mercury in two ways. Where an article of the treaty relates to a specific source of mercury, mercury pollution or activity involving mercury, that Article will be addressed in the corresponding section of this booklet (e.g. Article 7 of the treaty relates to ASGM and is described under section 9.1of this booklet entitled *Mercury Use in Artisanal and Small-Scale Gold Mining*). Where an Article of the treaty relates to other aspects of the treaty such as the preamble, procedural matters, timing, administrative and financial elements they are addressed in Annex 1 of this booklet.

The following Articles relate directly to mercury pollution issues and can be found at the designated section within this booklet as well as in Annex 1.

Article 3 Mercury supply sources and trade (see section 7.5)

Article 4 Mercury-added products (see section 8)

Article 5 Manufacturing processes in which mercury or mercury compound are used (see section 9.4)

Article 7 Artisanal and small-scale gold mining (see section 9.1)

Article 8 Emissions (air) (see section 10)

Article 9 Releases (land and water) (see section 10)

Article 10 Environmentally sound interim storage of mercury, other than waste mercury (see section 11.4)

Article 11 Mercury wastes (see section 11.2)

Article 12 Contaminated sites (see section 11)

Article 16 Health aspects (see section 5)

2.1 THE IPEN MINAMATA DECLARATION ON TOXIC METALS

While many aspects of the mercury treaty move countries forward from a consensus on the harmful impacts of mercury pollution toward positive action, IPEN also recognizes that more can be done to strengthen the effectiveness of the treaty. In addition to the legal obligations of the treaty, IPEN is of the view that naming the mercury treaty, *The Minamata Convention on Mercury*, creates a moral obligation for Parties to prevent outbreaks of Minamata disease, rigorously respond and resolve any Minamata-like tragedy and significantly reduce global levels of methyl mercury pollution in fish and sea food. Mercury pollution represents a large and serious threat to human health and the environment and a robust and ambitious global response to this threat is needed.

As an expression of these views, in the lead up to the adoption of the global mercury treaty in 2013, IPEN developed a comprehensive public statement regarding its platform on mercury and other toxic metals. This statement, entitled *The IPEN Minamata Declaration on Toxic Metals*, was adopted by IPEN's General Assembly in October 2013 and it was presented to Minamata disease victims and community supporters at the International Minamata Disease Symposium in Minamata, Japan.

The Declaration expresses solidarity with the victims of Minamata disease in their struggle for justice and affirms IPEN's intention to convert the policy positions in the mercury treaty into action on the ground to identify and eliminate mercury pollution. As part of this program to advance from policy to practice, IPEN promotes rapid ratification of the mercury treaty and implementation of mercury elimination activities through its participating organizations.

The full text of *The IPEN Minamata Declaration on Toxic Metals* is located at Annex 2 of this booklet.

3. MERCURY IN THE ENVIRONMENT

Mercury is a natural element whose chemical symbol is Hg. This abbreviation comes from the Greek word *hydrargyrum*, which means liquid silver. In its pure form, mercury is a silvery-white metal that is liquid at standard temperature and pressure. In different contexts, pure mercury is often called quicksilver, metallic mercury, or liquid mercury. Most commonly, however, pure mercury is called elemental mercury.

Because elemental mercury has high surface tension, it forms small, compact, spherical droplets when it is released into the environment. Although the droplets themselves are stable, the high vapor pressure of mercury compared with other metals causes the mercury to evaporate (or volatilize). In an indoor setting, mercury can quickly become an inhalation hazard. Outdoors, elemental mercury volatilizes and enters the atmosphere.[1]

Mercury is an element and it cannot be created by people, nor can it be destroyed. Mercury is released into the environment by volcanic eruptions, and it naturally occurs in the earth's crust, often in the form of mercury salts such as mercury sulfide. Mercury is present in very small quantities in uncontaminated soils at an average concentration of about 100 parts per billion (ppb). Rocks can contain mercury at concentrations between 10 and 20,000 ppb.[2] Many different kinds of human activities remove mercury from the earth's crust for some purpose, and this leads to releases of mercury into the general environment.

Elemental mercury can be produced for human use from an ore called cinnabar, which contains high concentrations of mercury sulfide. Elemental mercury can also be produced as a by-product from the mining and refining of metals such as copper, gold, lead and zinc. Mercury can also be recovered by recycling operations and is sometimes removed from natural gas or other fossil fuels.

It has been estimated that approximately one-third of the mercury circulating in the global environment is naturally occurring and approximately two-thirds was

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1 "Treatment Technologies for Mercury in Soil, Waste, and Water," U.S. EPA Office of Superfund Remediation and Technology Innovation, 2007, http://www.epa.gov/tio/download/remed/542r07003.pdf.

2 "Locating and Estimating Air Emissions from Sources of Mercury and Mercury Compounds," U.S. Environmental Protection Agency, 1997, http://www.epa.gov/ttnchie1/le/mercury.pdf.

originally released into the environment as a result of industrial and other human activities.[3] Besides volcanic eruptions, natural sources of mercury also include the weathering of rocks and soils. The amount of mercury that is circulating in the world's atmosphere, soils, lakes, streams and oceans has increased by a factor of between two and four since the start of the industrial era.[4] As a result, levels of mercury in our environment are dangerously high.

Whenever people intentionally produce and use mercury, much of that mercury will eventually volatilize into the atmosphere. Several kinds of human activities release mercury into the environment. Mercury is present in fossil fuels, metal ores and other minerals. When coal is burned, much of its mercury content enters the environment. Mercury emissions from coal burning are unintentional but are the second largest source of anthropogenic emissions after artisanal gold mining. Mining and refining metal ores and the manufacture of cement also release mercury into the environment. The largest present intentional use of mercury is by artisanal and small-scale gold miners. Mercury compounds are also sometimes used as catalysts or feedstocks in chemical manufacturing and in other industrial processes. Finally, mercury and mercury compounds are present in numerous kinds of consumer and industrial products.

After mercury enters the air, it moves with the wind and eventually falls back to earth. In the air, mercury may travel either a short or long distance before falling back to earth; it may even fully circle the globe. A portion of the mercury that falls into the ocean or onto the land will re-volatilize; it will again travel with the wind and will again fall back to earth somewhere else. The mercury that falls on land and does not volatilize will likely bind to organic material. Some becomes trapped in peat or soils. The remainder eventually drains to streams and rivers and then to lakes and oceans. In the aquatic environment, elemental mercury will likely become bound to sediment and then transported on ocean or river currents. Some mercury remains dissolved in the water column. In aquatic systems, naturally present microorganisms can transform mercury into methylmercury, an organometallic compound that is more toxic at low doses than pure mercury. Methylmercury becomes part of the aquatic food chain; it bioaccumulates and biomagnifies, and it can then be transported by migratory species.

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3 U.S. Environmental Protection Agency, http://www.epa.gov/mercury/control_emissions/global.htm.

4 Health Canada, http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/mercur/q1-q6_e.html.

MERCURY IN THE ATMOSPHERE

Most mercury in the atmosphere is in the gaseous state, but some is attached to particulate matter. Gaseous mercury is mostly elemental mercury, but a small percentage has been oxidized into mercury compounds such as mercury chloride and mercury oxide.

Pure mercury vapor, also called gaseous elemental mercury (GEM), has very low water solubility and is very stable in the atmosphere, with an estimated residence time of between six months and two years. This stability enables elemental mercury to undergo long range transport and causes GEM concentrations to be fairly uniform in the atmosphere. The more industrially developed Northern Hemisphere, however, has higher atmospheric GEM concentrations than does the Southern Hemisphere.

Mercury compounds present in the atmosphere in a gaseous state are often referred to as reactive gaseous mercury, or RGM. RGM compounds are more chemically reactive than GEM ones and are mostly soluble in water. RGM is much less atmospherically stable than GEM, and rain and other forms of precipitation can remove it from the atmosphere. This is called wet deposition. RGM can also be removed from the atmosphere without precipitation through a process called dry deposition.

RGM remains in the atmosphere for only a fairly short time. Particulate-bound mercury also spends a relatively short time in the atmosphere and can also be fairly quickly removed by both wet and dry deposition.

Because GEM is a gas that is not highly water soluble, precipitation does not efficiently remove it from the atmosphere. There are various mechanisms, however, by which GEM becomes subject to deposition, and these remain an ongoing subject of investigation. Some studies relate GEM depositions to photochemical reactions in the surface layers of the atmosphere. Some indicate that dry deposition of GEM can occur on forest canopies and that this is an important sink for atmospheric GEM. Another study has found indications that under certain conditions, GEM can be removed from the atmosphere at the ocean boundary. [5,6,7]

A relatively new phenomenon called an atmospheric mercury depletion event (AMDE) has been reported in the literature. Research in the Canadian high Arctic found that each spring, during polar sunrise, the atmospheric mercury concentration dropped sharply and at the same time, ozone present in surface air was depleted. AMDEs have been demonstrated in both the Arctic and the Antarctic regions. These depletion events are likely caused by photochemical reactions in the low atmosphere between ozone and halogen compounds of largely marine origin, especially bromine oxides. In this process, ozone is destroyed and elemental mercury that is present in the atmosphere is oxidized and converted into reactive gaseous mercury compounds. It is estimated that approximately 300 metric tons of this reactive mercury is deposited annually in the Arctic due to AMDEs. The result, apparently, is a doubling or more of the amount of mercury depositions in the Arctic in excess to what would be expected in the absence of these springtime depletion

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5 X. W. Fu et al., "Atmospheric Gaseous Elemental Mercury (GEM) Concentrations and Mercury Depositions at a High-Altitude Mountain Peak in South China," *Atmospheric Chemistry and Physics*, 2010, http://www.atmos-chem-phys.net/10/2425/2010/acp-10-2425-2010.pdf.

6 E.-G. Brunke et al., "Gaseous Elemental Mercury Depletion Events Observed at Cape Point During 2007–2008," *Atmospheric Chemistry and Physics*, 2010, http://www.atmos-chem-phys.net/10/1121/2010/acp-10-1121-2010.pdf.

7 "Fact Sheet: Mercury—A Priority Pollutant," Arctic Monitoring and Assessment Programme, 2005, http://mst.dk/media/mst/67134/AMA-PACAPMercury.pdf

events. Furthermore, these AMDE mercury depositions appear to be in the form of bio-available oxidized mercury compounds.[8,9,10] The discovery of the AMDE phenomenon helps further explain why Arctic peoples are disproportionately impacted by methylmercury exposure.

Investigations into the mechanisms by which the mercury contained in atmospheric GEM gets deposited onto land and water are ongoing.

SOME PROPERTIES OF ELEMENTAL MERCURY

Property	**Value**
Atomic Weight	200.59
Atomic Number	80
Melting Point	-38.87°C
Boiling Point	356.58°C
Vapor Pressure at 25°C	2 x 10-3 mm Hg
Solubility in Water at 25°C	20–30 ↔g/L
CAS Registry Number	7439-97-6
Mass	13.5336 gm/cc

8 A. Steffen et al., "A Synthesis of Atmospheric Mercury Depletion Event Chemistry in the Atmosphere and Snow," *Atmospheric Chemistry and Physics*, 2008, http://www.atmos-chem-phys.org/8/1445/2008/acp-8-1445-2008.pdf.

9 Jens C. Hansen et al., "Exposure of Arctic Populations to Methylmercury from Consumption of Marine Food: An Updated Risk-Benefit Assessment," *International Journal of Circumpolar Health* 64:2, 2005.

10 Laurier Poissant et al., "Critical Review of Mercury Fates and Contamination in the Arctic Tundra Ecosystem," *Science of the Total Environment* 400, 2008, 173-211.

4. TOXICOLOGICAL EFFECTS OF MERCURY AND METHYLMERCURY

Knowledge that mercury is toxic goes back to at least the first century C.E. when the Roman scholar Pliny described mercury poisoning as a disease of slaves, noting that mines contaminated by mercury vapor were considered too unhealthy for Roman citizens.[11]

In popular culture mercury poisoning has been associated with the Mad Hatter, a character that appears in the story *Alice's Adventures in Wonderland*. In the nineteenth century, workers in the English hat-making industry frequently suffered neurological symptoms such as irritability, shyness, depression, tremors and slurred speech. Exposure to a mercury compound, mercuric nitrate—a chemical that was then widely used in making felt hats— caused these symptoms. Many believe that these poisoned workers were the source of the common English-language expression "mad as a hatter" and were the inspiration for the Mad Hatter character.[12]

Occupational exposure to mercury is not just a problem from the past. It remains a problem today for workers in many industries such as mercury mining; chlor-alkali production; the manufacturing of thermometers, fluorescent lamps, batteries, and other mercury-containing products; gold, silver, lead, copper, and nickel mining and refining; and the field of dentistry. The largest-scale exposures are suffered by the millions who work in artisanal and small-scale gold mining. These miners use elemental mercury to separate gold from ore¸ usually under uncontrolled or poorly controlled conditions. As a result, the miners, their families and their communities are highly exposed.

The nervous system is very sensitive to all forms of mercury. Methylmercury and metallic mercury vapors are especially harmful because mercury in these forms more readily reaches the brain. Exposure to high levels of metallic, inorganic, or organic mercury can permanently damage the brain and kidneys and has been

11 Encyclopedia Britannica Online, February 20, 2010, http://www.britannica.com/EBchecked/topic/424257/occupational-disease.

12 "NIOSH Backgrounder: Alice's Mad Hatter and Work-Related Illness," U.S. National Institute for Occupational Safety and Health, March 2010, http://www.cdc.gov/niosh/updates/upd-03-04-10.html.

shown to affect a developing fetus, even months after the mother's exposure. The harmful effects that can be passed from the mother to the fetus include brain damage, mental retardation, blindness, seizures and the inability to speak. Children poisoned by mercury may develop problems in their nervous and digestive systems and kidney damage. Adults who have been exposed to mercury have symptoms such as irritability, shyness, tremors, changes in vision or hearing and memory problems. Short-term exposure to high levels of metallic mercury vapors may cause effects such as lung damage, nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes and eye irritation.[13]

A guidance document prepared jointly by the World Health Organization (WHO) and the United Nations Environmental Program (UNEP) stated the following:

"The primary targets for toxicity of mercury and mercury compounds are the nervous system, the kidneys, and the cardiovascular system. It is generally accepted that developing organ systems (such as the fetal nervous system) are the most sensitive to toxic effects of mercury. Fetal brain mercury levels appear to be significantly higher than in maternal blood, and the developing central nervous system of the fetus is currently regarded as the main system of concern as it demonstrates the greatest sensitivity. Other systems that may be affected include the respiratory, gastrointestinal, hematologic, immune, and reproductive systems."[14]

4.1 ELEMENTAL MERCURY AND INORGANIC MERCURY SALTS

People can be poisoned by pure elemental mercury by inhaling mercury vapors. Approximately 80 percent of inhaled mercury vapor is absorbed by the respiratory tract or through the sinuses and then enters the circulatory system to be distributed throughout the body.[15] Chronic exposure by inhalation, even at low concentrations, has been shown to cause effects such as tremors, impaired cognitive skills

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13 "ToxFAQs for Mercury," Agency for Toxic Substances and Disease Registry, 1999, http://www.atsdr.cdc.gov/tfacts46.html#bookmark05.

14 "Guidance for Identifying Populations at Risk from Mercury Exposure," UNEP DTIE Chemicals Branch and WHO Department of Food Safety, Zoonosis, and Foodborne Diseases, 2008, p.4., http://www.unep.org/hazardoussubstances/Mercury/MercuryPublications/GuidanceTrainingmaterialToolkits/GuidanceforIdentifyingPopulationsatRisk/tabid/3616/language/en-U.S./Default.aspx

15 Wikipedia entry on mercury poisoning, M.G. Cherian, J.G. Hursh, and T.W. Clarkson, "Radioactive Mercury Distribution in Biological Fluids and Excretion in Human Subjects after Inhalation of Mercury Vapor," *Archives of Environmental Health* 33, 1978: 190-214.

and sleep disturbance in workers.[16] Elemental mercury vapors can be found in many industrial workplaces and can also be present in hospitals, dentist offices, schools and homes where mercury-containing products are used. Exposure from inhaling these mercury vapors poses a significant risk.

On the other hand, elemental mercury in its liquid form differs from most inorganic and organic mercury compounds in that it is not easily absorbed into the body if someone ingests it or is exposed by skin contact. Animal data suggests that less than 0.01 percent of ingested elemental mercury is absorbed by the stomach and intestines. Cases of people being poisoned by swallowing metallic elemental mercury are rare.[17]

Inorganic mercury salts, on the other hand, can be highly toxic and corrosive. Acute exposure to inorganic mercury salts can cause corrosive damage to the stomach and intestines and can also cause significant kidney damage. If mercury salts are eaten or are in contact with the skin, the body can absorb them at a rate of about 10 percent of the amount ingested, which harms various organ systems including the central nervous system. The rate at which the body absorbs inorganic mercury salts is much greater than the absorption rate of elemental mercury, but lower than the absorption rates of organic mercury compounds such as methylmercury, which, when ingested, are absorbed almost completely by the stomach and the intestines.[18]

4.2 METHYLMERCURY

Methylmercury ($CH3Hg+$) is the form of mercury that is mainly responsible for mercury pollution in fish, shellfish and the birds and mammals that eat them. When a person ingests methylmercury, the stomach and intestines absorb it much more completely than they absorb inorganic mercury.[19]

There appear to be a number of different ways in which mercury is transformed in the environment into methylmercury, and researchers are actively investigating

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16 Wikipedia entry on mercury poisoning, C.H. Ngim, S.C. Foo, K.W. Boey, and J. Keyaratnam, "Chronic Neurobehavioral Effects of Elemental Mercury in Dentists," *British Journal of Industrial Medicine* 49 (11), 1992; and Y.X. Liang, R.K. Sun, Z.Q. Chen, and L.H. Li, "Psychological Effects of Low Exposure to Mercury Vapor: Application of Computer-Administered Neurobehavioral Evaluation System," *Environmental Research* 60 (2), 1993: 320–327.

17 Wikipedia entry on mercury poisoning, T.W. Clarkson and L. Magos, "The Toxicology of Mercury and Its Chemical Compounds," *Critical Reviews in Toxicology* 36 (8), 2006: 609-62.

18 Barry M Diner et al., "Toxicity, Mercury," eMedicine, 2009, http://emedicine.medscape.com/article/819872-overview.

19 Ibid.

these. One important process of biomethylation is carried out by bacteria that live in water with low levels of dissolved oxygen. In fresh and brackish water, this can occur in the sediments of estuaries and lake bottoms.[20] Methylmercury can also be formed in oceans when mercury falls from the atmosphere to the ocean surface and is transported to the ocean depths where naturally occurring bacteria decompose organic matter and, at the same time, also convert mercury to methylmercury.[21] Once in the environment, methylmercury bioaccumulates and biomagnifies as larger organisms eat smaller ones.

Methylmercury differs from metallic mercury in that when a person eats food contaminated with methylmercury, the stomach and intestines rapidly absorb it into the bloodstream. From there, it readily enters the brain of an adult, a child, or a developing fetus. In the brain, methylmercury accumulates and is slowly converted to inorganic (elemental) mercury.[22]

In 2000, the United States Environmental Protection Agency (U.S. EPA) asked the National Research Council of the National Academies of Sciences and Engineering to perform a study on the toxicological effects of methylmercury. The study found that the population at highest risk for methylmercury exposure is the children of women who consumed large amounts of fish and seafood during or immediately prior to pregnancy. It found that the risk to this population is likely to be sufficient to result in an increase in the number of children who must struggle to keep up in school and who might require remedial classes or special education.[23] It should be noted that studies have found that when children suffer these kinds of neurological deficits from exposure to pollutants, they are generally less successful in their later lives as measured by lifelong earnings. Such deficits not only harm exposed individuals and their families, but also can have a cumulative impact on society through increased costs for schooling and care for affected individuals and by decreasing national productivity.[24]

Neurological Effects

The developing nervous system is more sensitive to the toxic effects of methylmercury than is the developed nervous system, although both the adult and fetal

[20] Definition of methylmercury, U.S. Geological Survey, http://toxics.usgs.gov/definitions/methylmercury.html.

[21] *A New Source of Methylmercury Entering the Pacific Ocean*, U.S. Geological Survey, http://toxics.usgs.gov/highlights/pacific_mercury.html.

[22] "Toxicological Effects of Methylmercury," The Committee on the Toxicological Effects of Methylmercury, the Board on Environmental Studies and Toxicology, and the National Research Council, 2000, p.4, http://www.nap.edu/catalog.php?record_id=9899#toc.

[23] Ibid., p. 9.

[24] Philip Landrigan et al., "Environmental Pollutants and Disease in American Children," http://ehp.niehs.nih.gov/members/2002/110p721-728landrigan/EHP110p721PDF.PDF.

brain is susceptible.[25] Prenatal exposures interfere with the growth of developing neurons in the brain and elsewhere and have the potential to cause irreversible damage to the developing central nervous system. After exposures associated with chronic maternal fish consumption, infants might appear normal during the first few months of life but might later display deficits in subtle neurological end points such as deficits in IQ; abnormal muscle tone; and losses in motor function, attention, and visuospatial performance.[26]

The weight of evidence for developmental neurotoxic effects from exposure to methylmercury is strong. There is a strong database including multiple human studies and experimental evidence in animals and in vitro tests. Human studies include evaluations of both sudden, high-exposure scenarios and chronic, low-level exposure.[27]

Heart Disease and High Blood Pressure

Researchers have found a correlation between consumption of methylmercury-contaminated fish and the risk of heart attack. A study of fishermen found that eating more than 30 grams (g) of fish per day doubled or tripled their risk of heart attack or cardiovascular death. Blood pressure elevations have also been observed in occupationally exposed men.[28]

Immune System Effects

Occupational studies suggest that mercury exposure can affect the immune system in humans. In vitro and animal studies have shown that mercury can be toxic to the immune system and that prenatal exposure to methylmercury can produce long-term effects on the developing immune system. Studies suggest that exposure to methylmercury can increase human susceptibility to infectious diseases and autoimmune disorders by damaging the immune system.[29]

Cancer

Two studies have found associations between mercury exposure and acute leukemia, but the strength of the findings is limited because of the small study populations and lack of control for other risk factors. Mercury exposure has also been associated with kidney tumors in male mice, and mercury has also been shown to cause chromosomal damage. On the basis of the available human, animal and in

25 Ibid., 22, p. 310.
26 Ibid., p. 17.
27 Ibid., p. 326.
28 Ibid., p.18, 309-10.
29 Ibid., p. 308.

vitro data, the International Agency for Research on Cancer (IARC) and the U.S. EPA have classified methylmercury as a possible (EPA Class C) human carcinogen.[30]

Reproductive Effects

The reproductive effects of methylmercury exposure have not been adequately evaluated in humans. However, an evaluation of the clinical symptoms and outcomes of more than 6,000 people exposed to methylmercury during a wheat-contamination incident in Iraq found a lowered rate of pregnancies (a 79 percent reduction), providing suggestive evidence of an effect of methylmercury on human fertility. Animal studies, including work in nonhuman primates, have found reproductive problems, including decreased conception rates, early fetal losses, and stillbirths.[31]

Effects on the Kidneys

Metallic mercury and methylmercury are both also known to be toxic to the kidneys. Kidney damage has been observed following human ingestion of organic forms of mercury at exposure levels that also cause neurological effects. Animal studies have also described methylmercury-induced toxicity to the kidneys.[32]

4.3 ENVIRONMENTAL IMPACTS OF METHYLMERCURY

The ecological impacts of methylmercury pollution have been less well-studied than its human toxicity. We do know, however, that methylmercury accumulates in fish at levels that may harm the fish and animals that eat them. Birds and mammals that eat fish are generally more exposed to methylmercury than other animals in water ecosystems. Similarly, predators that eat fish-eating animals are at risk. According to an EPA report, methylmercury has been found in eagles, otters and endangered Florida panthers, and analyses conducted for the report suggest that some highly exposed wildlife species are being harmed by methylmercury. Effects of methylmercury exposure on wildlife can include death, reduced fertility, slower growth and abnormal development and behavior patterns that can affect survival. In addition, the levels of methylmercury found in the environment

30 Ibid., p. 308.
31 Ibid., p. 309.
32 Ibid., p. 18, 309.

may alter the endocrine system of fish, and this may impact their development and reproduction.[33,34]

In birds, mercury exposure can interfere with reproduction when concentrations in eggs are as low as 0.05 milligrams (mg) to 2.0 milligrams per kilogram (kg). The eggs of certain Canadian species are already in this range, and mercury concentrations in the eggs of several other Canadian species continue to increase and are approaching these levels. Mercury levels in Arctic ringed seals and beluga whales have increased by two to four times over the last 25 years in some areas of the Canadian Arctic and Greenland.[35] There are also indications that predatory marine mammals in warmer waters may be at risk. In a study of Hong Kong's population of hump-backed dolphins, mercury was identified as a particular health hazard.[36]

Recent evidence also suggests that mercury is responsible for a reduction of microbiological activity vital to the terrestrial food chain in soils over large parts of Europe and potentially in many other places in the world with similar soil characteristics.[37]

Rising water levels associated with global climate change may also have implications for the methylation of mercury and its accumulation in fish. For example, there are indications of increased formations of methylmercury in small, warm lakes and in many newly flooded areas.[38]

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33 "Environmental Effects: Fate and Transport and Ecological Effects of Mercury," U.S. Environmental Protection Agency, http://www.epa.gov/hg/eco.htm.

34 "Poisoning Wildlife: The Reality of Mercury Pollution," National Wildlife Federation, September 2006, http://www.nwf.org/nwfwebadmin/binaryVault/PoisoningWildlife-MercuryPollution1.pdf.

35 F. Riget, D. Muir, M. Kwan, T. Savinova, M. Nyman, V. Woshner, and T. O'Hara, "Circumpolar Pattern of Mercury and Cadmium in Ringed Seals, Science of the Total Environment, 2005, p. 351-52, 312-22.

36 "Global Mercury Assessment: Summary of the Report," chapter 5, UNEP, 2003, http://www.chem.unep.ch/mercury/Report/Summary%20of%20the%20report.htm#Chapter5.

37 Ibid.

38 Ibid.

5. MERCURY POLLUTION AND HUMAN HEALTH

Minamata disease is a serious and often-deadly illness caused by exposure to high levels of methylmercury. It is associated with hot spots of acute mercury pollution from certain industrial processes and mercury-contaminated wastes. Mercury pollution, however, also causes harm to human health and the environment at locations far from industrial or other local mercury sources. In all regions of the world, fish and shellfish from ponds, streams, rivers, lakes and oceans are commonly contaminated by methylmercury in concentrations that can cause significant health deficits to the people who eat them, especially people who depend on fish and shellfish as a major source of protein.

While Minamata disease has become the iconic representation of acute mercury poisoning, the full range of human health effects from exposure to different forms and concentrations of mercury is still subject to research. The most subtle effects of mercury as a neurotoxin are becoming clearer to researchers who have identified subtle large-scale population impacts on cognitive ability and IQ as a result of global mercury pollution.[39]

What does the mercury treaty say about health aspects of mercury?

The mercury treaty addresses human health actions by Parties to the Treaty under Article 16. While it does not contain mandatory provisions, it encourages Parties to the Treaty to promote a range of health related measures. This provides an opportunity for NGOs to collaborate with national governments, universities and the healthcare sector to undertake studies and other activities to identify and protect those populations who are particularly vulnerable to mercury pollution due to their occupation, diet or other circumstance. In a related provision under section 17 (Information exchange), an important sub-clause (5) states that, "information on the health and safety of humans and the environment shall not be regarded as confidential."

Article 16 Health aspects

- The treaty text states that "Parties are encouraged to...undertake health related activities."

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[39] Grandejean, P., and Landrigan P.J., (2006) Developmental neurotoxicity of industrial chemicals. Lancet. 2006 Dec 16;368(9553):2167-78.

- Optional activities include:
  - Strategies and programs to identify and protect populations at risk;
  - Development and implementation of science-based educational and preventive programs on occupational exposure to mercury;
  - Promoting appropriate health-care services for prevention, treatment, and care of populations affected by mercury exposure; and
  - Establishing and strengthening institutional and health professional capacities for prevention, diagnosis, treatment, and monitoring of health risks related to mercury exposure.
- The Conference of Parties (COP) should consult with WHO, International Labour Organization (ILO), and other relevant intergovernmental organizations as appropriate.
- The COP should promote cooperation and exchange of information with WHO, ILO, and other relevant intergovernmental organizations.

How can NGOs use the mercury treaty to campaign on human health aspects of mercury pollution?

Engaging institutions on mercury health issues

NGOs can use the provisions of this article to approach governments, academic institutions and health sector professionals with information they may have on demonstrated and suspected health impacts of mercury in their country and seek to establish programs to address these health issues. As the provisions are not mandatory, NGOs could accelerate these health-related activities by identifying health issues they are aware of (e.g. mercury contamination of rivers from ASGM activity) and encouraging government to develop programs to identify the populations at risk, study the impacts and establish diagnostic and treatment capacity. Working with health care institutions may also provide opportunities to develop up to date diagnostic and treatment services to identify populations and individuals at risk of mercury poisoning. This may also have the indirect benefit of identifying 'clusters' of impacted people and thereby identifying point sources of mercury pollution that may not otherwise be obvious.

Capacity building with health services

In many developing countries, the Ministry of Health does not have enough capacity to manage chemicals of concern and their impact on human health and the environment. This is often the case with non-communicable diseases from mercury and other heavy metals. NGOs can work with local health workers, health service providers and or with the Ministry of Health to start raising awareness among the health workers, practitioners and students about chemicals of concern, in this case mercury. Health workers and practitioners should have adequate knowledge about mercury, including how to identify mercury use and its routes of exposure in their neighborhood, communities or towns. They also should have the capacity to identify mercury poisoning symptoms and be able to associate it with the non-communicable diseases records or statistics. Capacity building for health workers and practitioners are key to implementing health initiatives and programs.

Implementation of biomonitoring programs

The Ministry of Health also should be encouraged to establish a coordinated and comprehensive biomonitoring program that can be conducted periodically to monitor and evaluate the living environment and be integrated into the National Implementation Plan for mercury elimination. The results should be made available to the public and accessible at anytime to anyone. Fish or food advisories should be provided based on the latest status of the mercury pollution in the country and or in specific areas such as the mercury pollution hotspots near the primary or historical mercury mining sites, near Artisanal and Small-scale Gold Mining (ASGM) sites, and near coal-fired power plants.

Seeking information on mercury health impacts

The related health clause under Article 17 which concludes, "For the purposes of this Convention, information on the health and safety of humans and the environment shall not be regarded as confidential" may provide leverage for NGOs to seek information from their government on known sources and impacts of mercury on citizens of their country. Information that has previously been classified may be able to be released and publicised raising awareness about mercury pollution in the community and exposing industries that may be responsible for creating mercury contamination. This can then lead to further NGO activities targeting mercury pollution sources for environmental monitoring, biomonitoring, clean up or tighter regulations. This clause could also stimulate efforts to establish a pollutant release and transfer registry (PRTR) or include mercury in a pre-existing registry.

5.1 ACUTE MERCURY POLLUTION AND MINAMATA DISEASE

The most famous example of acute mercury contamination occurred in fishing villages along the shore of Minamata Bay, Japan. Chisso, a chemical company located near the bay, used mercury sulfate and mercury chloride as catalysts in the production of acetaldehyde and vinyl chloride. Wastewater from the plant was discharged into Minamata Bay and contained both inorganic mercury and methylmercury. The methylmercury originated mainly as a side product of the acetaldehyde production process.[40] Methylmercury accumulated in the fish and shellfish in the bay and in local people who ate the fish and shellfish. The result was a form of mercury poisoning that is now known as Minamata disease.[41]

Minamata disease patients complained of a loss of sensation and numbness in their hands and feet. They could not run or walk without stumbling, and they had difficulties seeing, hearing, and swallowing. A high proportion died. The disease was first diagnosed in 1956. By 1959, a strong case had been made that the disease was caused by the high concentrations of methylmercury that were present in the fish and shellfish in the bay.

Mercury discharges from the Chisso plant into the bay were continuous from the time the factory started using the acetaldehyde-production process in 1932 until 1968, when the factory discontinued this production method. Production of vinyl chloride using a mercury catalyst continued at the plant until 1971, but after 1968 the wastewater was diverted to a special pond.[42]

Throughout this period, the scientific community's understanding of the cause of methylmercury-induced health effects was impaired due to a reliance on narrow case definitions and uncertain chemical speciation. Although methylmercury was known to be capable of producing developmental neurotoxicity as early as 1952, it took another 50 years for researchers to understand the vulnerability of the developing nervous system to heavy metals such as methylmercury. Additionally, normal uncertainties of the kind associated with virtually all new environmental health research delayed for years the achievement of a scientific consensus as to the cause of the people's symptoms. This, in turn, caused long delays before the pollution source was finally stopped, and it caused even longer delays in reaching decisions to compensate the victims.[43]

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40 "Environmental costs of mercury pollution," Lars D. Hylander et al, Science of the Total Environment, 2006, http://www.elsevier.com/authored_subject_sections/P09/misc/STOTENbestpaper.pdf.

41 "Minamata disease," Wikipedia, http://en.wikipedia.org/wiki/Minamata_disease and "The Poisoning of Minamata," Douglas Allchin, http://www1.umn.edu/ships/ethics/minamata.htm

42 Ibid., 40

43 Grandjean, P.,Satoh, H.,Murata, K. Eto, K., (2010). Adverse effects of methylmercury: environmental health research implications. Environ Health Perspect 118(8): 1137-1145 http://ehp03.niehs.nih.gov/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1289%2Fehp.0901757.

In May 2010, more than 50 years after the disease was first diagnosed, the Government of Japan adopted additional redress measures for unrecognized Minamata disease sufferers and promised further efforts. Then Japanese Prime Minister Yukio Hatoyama participated in the 54th annual Minamata commemoration ceremony and apologized for the government's inability to prevent the spread of the disease in the country's worst industrial pollution case. In his speech, he expressed hope that Japan will actively contribute to creating an international treaty for preventing future mercury poisoning and proposed naming it the Minamata Treaty.[44]

Nevertheless, a number of outstanding issues still impact Minamata victims and the Minamata community. Although 2,273 individuals were officially recognized as Minamata disease patients as of 2011, several tens of thousands have neurological symptoms characteristic of methylmercury poisoning, but remain formally unrecognized. Approximately 65,000 people have applied to the government for relief for Minamata disease. Corporate restructuring, undertaken with the approval of the Japanese government, has also limited Chisso's liability for Minamata disease sufferers.

Medical criteria used by the Japanese government to assess and certify victims of Minamata disease was declared medically invalid by the Japanese Society of Psychiatry and Neurology (JSPN) in 1998 (JSPN, 1998) and invalid by the Supreme Court in 2004.[45] The Chisso Corporation has also failed to remove massive amounts of mercury contaminated waste still held in 'temporary' containment structures around the town of Minamata for decades. The engineered structures are nearing the end of their operational lives and are at risk of leaking mercury back into the environment. They are also at high risk from earthquakes and tsunamis.

The failure of the Japanese government to address these issues and hold Chisso to account has led to ongoing resentment among Minamata residents and organizations that represent victims of the mercury contamination.

A second outbreak of Minamata disease occurred in 1965 in Japan in the Agano River basin in the Niigata Prefecture. A different chemical company, producing acetaldehyde using a mercury sulfate catalyst and a similar process, dumped its wastewater into the Agano River. The Japanese government certified 690 people as patients in this outbreak of the disease.

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44 "Hatoyama Apologizes for Minamata; At Memorial Service, Says Redress Not End of Matter," *The Japan Times*, May 2, 2010, http://search.japantimes.co.jp/cgi-bin/nn20100502a1.html.

45 McCurry, J. (2006). Japan remembers Minamata. Lancet, 367(9505), 99-100.

Another example of Minamata disease occurred in the early 1970s in Iraq when an estimated 10,000 people died and 100,000 were severely and permanently brain damaged from eating wheat that had been treated with methylmercury.[46] Another example is the poisoning of Canadian aboriginal people at Grassy Narrows, which was caused by mercury discharges from a chlor-alkali plant and pulp and paper mill in Dryden, Ontario, between 1962 and 1970.[47]

Less well-known and less dramatic cases of acute mercury pollution continue to occur. According to the late Masazumi Harada, a leading world expert on Minamata disease, "Rivers in the Amazon, Canada, and China have been affected by mercury poisoning, but as with Minamata disease, there are few patients who look severely ill at first glance. People are clearly affected by mercury, but the mercury is found in small amounts in patients' bodies, or they are still in the initial stages of the disease."[48]

5.2 MERCURY-CONTAMINATED FISH

Acute mercury pollution, however, is just one part of a much bigger picture. Widespread mercury pollution at levels of concern can be found in oceans, lakes, rivers, ponds and streams in all parts of the world.

As indicated earlier, mercury enters water bodies mainly by falling directly from the air and through drainage from mercury-contaminated soils. Upon entering the aquatic environment, a significant fraction of the mercury is transformed into methylmercury by microorganisms that are naturally present in these ecosystems. The microorganisms are eaten by small aquatic organisms that are, in turn, eaten by fish and shellfish. These are then eaten by larger fish, birds, mammals, and people.

Methylmercury starts at the bottom of the food chain and then accumulates and biomagnifies as larger organisms eat smaller ones. As a result of this biomagnification, the concentration of methylmercury in some fish species can be at levels in the range of a million times (106) greater than the background concentration of the mercury in the water that the fish inhabit.[49]

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46 Arne Jernelov, "Iraq's Secret Environmental Disasters," http://www.project-syndicate.org/commentary/jernelov3/English.

47 "Grassy Narrows Protests Mercury Poisoning," CBC News, April 7, 2010, http://www.cbc.ca/canada/toronto/story/2010/04/07/tor-grassy-narrows.html.

48 Asahi Shimbun, "Interview with Masazumi Harada," Asia Network, http://www.asahi.com/english/asianet/hatsu/eng_hatsu020923f.html.

49 Health Canada, http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/mercur/q47-q56_e.html.

Mercury pollution of water bodies is very widespread. Water bodies located downwind or downstream of heavy mercury-polluting sources such as large coal-fired power plants, cement kilns, mines, waste dumps, chlor-alkali facilities, pulp and paper mills, and other large industrial sources often have particularly high levels of mercury contamination. However, even in the Arctic region at locations far distant from any significant mercury-polluting sources, researchers have found a number of communities where people's dietary intake of mercury exceeds established national guidelines, and they have found evidence of resulting harm to children's nervous systems and related behavioral effects.[50] A study by the United States Geological Survey (U.S.GS) sampled predatory fish in streams at 291 locations spread throughout the United States. The researchers found that mercury was present in every fish they sampled, and 27 percent of the samples exceeded the U.S. EPA human-health criterion of 0.3 micrograms of methylmercury per gram wet weight.[51]

Many governments provide recommendations, guidelines, or legal limits for the maximum amount of mercury and/or methylmercury that should be allowed in fish that are to be sold on the market. However, not all guidelines established are enforceable, and many NGOs argue that they are too permissive to adequately protect public health. In some cases, the fishing industry has successfully beaten back efforts by government agencies to establish stricter standards with arguments that doing so would hurt sales.

The Codex Alimentarius Commission—a body established by the United Nations Food and Agriculture Organization (FAO) and the WHO to set internationally recognized food safety standards—has set guideline levels of 0.5 micrograms of methylmercury per gram in non-predatory fish and 1 microgram of methylmercury per gram in predatory fish. The U.S. Food and Drug Administration (FDA) has set an action level of 1 microgram of methylmercury per gram in both fish and shellfish – substantially higher than the U.S. EPA human-health criterion. The European Community allows 0.5 micrograms of methylmercury per gram in fishery products (with some exceptions). Japan allows up to 0.4 micrograms of total mercury per gram in fish or 0.3 micrograms of methylmercury per gram of

[50] Arctic Monitoring and Assessment Programme, "Executive Summary to the Arctic Pollution 2002 Ministerial Report," http://www.amap.no/documents/index.cfm?dirsub=/AMAP%20Assessment%202002%20-%20Human%20Health%20in%20the%20Arctic.

[51] Barbara C. Scudder et al., "Mercury in Fish, Bed Sediment, and Water from Streams Across the United States, 1998–2005," U.S. Geological Survey, 2009, http://pubs.usgs.gov/sir/2009/5109/pdf/sir20095109.pdf.

fish.[52] The Canadian Food Inspection Agency's guideline for the commercial sale of fish is 0.5 micrograms of total mercury per gram of fish wet weight, and Health Canada has established a guideline of 0.2 micrograms of total mercury per gram wet weight for frequent consumers of fish.[53]

In general, large predatory fish have the highest levels of methylmercury in their tissues; larger fish and older fish tend to be more contaminated than smaller fish and younger fish. Methylmercury in fish is bound to tissue protein rather than fatty tissue. Therefore, trimming and skinning mercury-contaminated fish ***does not*** reduce the mercury content of the fillet portion. Nor is the methylmercury level in fish reduced by cooking.[54]

A guidance document jointly prepared by the U.S. EPA and FDA states that nearly all fish and shellfish contain traces of mercury, and that some fish and shellfish contain levels that may harm a fetus or young child's developing nervous system. The risk, of course, depends on the amount of fish and shellfish eaten and the levels of mercury they contain. The guidance document advises pregnant women, nursing mothers, women who may become pregnant and young children to completely avoid eating fish species that typically contain unacceptably high levels of mercury such as shark, swordfish, king mackerel, and tilefish. It further advises that they eat no more than 12 ounces (340 grams) per week of fish and shellfish that are lower in mercury. On average, this means they should eat no more than two fish meals per week. The guidance document finally suggests they check local advisories about the safety of locally caught fish and, if no reliable advice is available, limit themselves to only one meal per week of locally caught fish.[55]

The guidance document, nonetheless, suggests that fish and shellfish not be completely eliminated from the diet. It notes that, mercury aside, fish and shellfish are a very nutritional food source. They contain high-quality protein and other essential nutrients, are low in saturated fat and contain omega-3 fatty acids that

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52 "Guidance for Identifying Populations at Risk from Mercury Exposure," UNEP DTIE Chemicals Branch and WHO Department of Food Safety, Zoonoses, and Foodborne Diseases, 2008, p. 4, http://www.who.int/foodsafety/publications/chem/mercuryexposure.pdf.

53 Lyndsay Marie Doetzel, "An Investigation of the Factors Affecting Mercury Accumulation in Lake Trout, Salvelinus Namaycush, in Northern Canada," http://library2.usask.ca/theses/available/etd-01022007-094934/unrestricted/LyndsayThesis.pdf.

54 Ibid., p. 8.

55 "What You Need to Know About Mercury in Fish and Shellfish: Advice for Women Who Might Become Pregnant, Women Who are Pregnant, Nursing Mothers, and Young Children," U.S. Department of Health and Human Services and U.S. Environmental Protection Agency, March 2004, http://www.epa.gov/waterscience/fish/advice/advisory.pdf.

are important for nutrition.[56] Health experts often recommend choosing fish to eat that are low in mercury and high in omega-3 fatty acids.

Unfortunately, fish-consumption advice can be confusing and hard to follow. There is great variability in levels of mercury in fish depending on the species, the location where the fish was caught, its size, the time of the year and other considerations. Choices are further complicated by the fact that in highly industrial countries, the fish at the market or on the restaurant menu is likely to have been shipped in from half a world away. Nonetheless, in wealthy countries, most women and children can choose if they wish to limit their fish consumption to no more than two fish meals per week and still maintain a nutritious diet by replacing fish with other protein-rich foods. However, there are many people in the world for whom restricting fish consumption may not be a realistic option.

In industrial countries such as the United States, Canada, and others, some indigenous people and some poor people catch their own fish and shellfish (and in some cases, fish-eating birds and mammals) and rely on these foods as their main sources of protein. They often cannot afford, or may otherwise lack access to, good alternative nutritious foods. In the developing world, even larger numbers of people depend on fish. People living on islands, in coastal regions and along inland waterways often have traditional diets that are highly dependent on fish for nutrition. The FAO estimates[57] that fish provide more than 2.9 billion people with at least 15 percent of their average per capita animal protein intake. Additionally, fish, on average, provide 50 percent or more of animal protein consumption for people in some small-island developing states and also in Bangladesh, Cambodia, Equatorial Guinea, French Guiana, the Gambia, Ghana, Indonesia, and Sierra Leone. The FAO reports that fish provide nearly 8 percent of animal protein consumption in North and Central America, more than 11 percent in Europe, about 19 percent in Africa, and nearly 21 percent in Asia. (Summary fish consumption figures for South America were not provided.) The report also notes that actual consumption is likely considerably higher than the figures provided because official statistics do not record the contribution of subsistence fishing.

Even considering the negative health impacts of eating large amounts of mercury-contaminated fish and shellfish, there are many people for whom severely restricting their fish consumption may be a bad choice or may be no choice at all. Some cannot reduce their fish consumption without facing hunger or starvation. For others, the main available substitute foods that would replace fish are high in sugars and low in protein. Restricting fish consumption in favor of such foods

56 Ibid.

57 "The State of World Fisheries and Aquaculture," Food and Agriculture Organization of the United Nations, 2008, p. 9, 61, ftp://ftp.fao.org/docrep/fao/011/i0250e/i0250e.pdf.

can lead to increases in obesity, diabetes, heart disease, and other diseases. For communities whose access to nutritious alternative foods is limited, the health benefits of fish consumption may, on balance, outweigh the health risks associated with mercury exposure. Members of these communities will continue to suffer the health consequences of exposure to methylmercury until international action is successful in significantly reducing mercury contamination in fish. In addition, many indigenous people and others have important cultural and social reasons for continuing to eat their traditional foods.

MERCURY IMPACTS ON ARCTIC PEOPLES

People living in the Arctic region, especially indigenous people, are particularly vulnerable to mercury exposure. Their climate does not allow them to grow grains or vegetables, which are often dietary staples in other parts of the world. Because they often live in remote locations, store-bought food tends to be prohibitively expensive, especially healthy, perishable foods. They therefore have little choice but to survive on a diet that is not only heavy in fish, but also in mammals and birds that eat fish. The lives of Arctic indigenous peoples living in the far northern regions of highly industrial countries are similar in many ways to the lives of most people in the developing world.

Inuit people live in the coastal Arctic in Northern Canada, Greenland, Alaska (U.S.), and Chukotka (Russia). The staple of their traditional diet is sea mammals. A study of mercury exposure in Inuit preschool children living in Nunavut, Canada, found that nearly 60 percent of them ingest mercury in amounts that exceed the provisional tolerable weekly intake (PTWI) level for children established by the WHO in 1998. This PTWI is 1.6 micrograms of methylmercury per kilogram of body weight per week. The average mercury intake for all the children participating in the study was 2.37 micrograms of methylmercury per kilogram of body weight per week. Of this mercury intake, 33.37 percent came from eating the muktuk (blubber and skin) of beluga whales, 25.90 percent came from eating narwhal muktuk,14.71 percent came from eating ringed seal liver, 10.60 percent came from eating fish, 6.02 percent came from eating caribou meat, and 4.59 percent from eating ringed seal meat. These sources made up more than 95 percent of the children's total mercury intake.[58]

Other Arctic indigenous people are also disproportionately impacted by exposure to methylmercury. Villages populated by indigenous Athabascan peoples are located throughout the North American Arctic, mostly along the great rivers. Trapping, hunting, and fishing remain crucial to their subsistence livelihoods. In the summer, families often leave the village for large fish camps.[59] The traditional livelihood of the Sami peoples of Norway, Sweden, Finland, and the Kola Peninsula of Russia includes semi-nomadic reindeer herding, coastal fishing, fur trapping and

58 "Mercury Hair Concentrations and Dietary Exposure Among Inuit Preschool Children in Nunavut, Canada," Tian W. et al, Environ Int. 2010, http://www.ncbi.nlm.nih.gov/pubmed/20673686

59 Tricia Brown, *Athabascan*, LitSite Alaska, http://www.litsite.org/index.cfm?section=Digital-Archives&page=People-of-the-North&cat=Native-Peoples&viewpost=2&ContentId=2648.

sheep herding.[60] There have been suggestions that polar sunrise atmospheric mercury depletion events, which result in the deposition of large quantities of bio-available mercury compounds on the Arctic tundra, amplify the presence of mercury in the tundra food web. This, together with aquatic methylmercury pollution, contributes to significant methylmercury accumulations in the traditional foods of these and other Arctic peoples.[61]

5.3 MERCURY-CONTAMINATED RICE

A number of recent studies have looked at mercury pollution in some inland regions of China where most inhabitants eat little fish but live in areas where considerable mercury is released into the environment.[62] The researchers noted that rice paddy soil is a suitable environment for the kind of bacteria that transform mercury into methylmercury. They therefore considered the possibility that methylmercury produced in the paddy soil might be taken up by the rice plants. The study looked at rural people who mainly eat local agricultural products and concluded that 95 percent of the total methylmercury exposure among these people came from rice.

For most people studied, exposure to methylmercury from eating rice was low compared with what is currently thought to be a tolerable weekly intake, and the researchers concluded these people probably face low risk. However, some of the people studied were in an area near mercury mines. Their exposure to methylmercury from eating rice greatly exceeded what is thought to be the tolerable weekly intake, and they were considered to be at a potential health risk.

The authors noted that rice does not contain certain micronutrients that are present in fish—micronutrients that enhance neurodevelopment and that may possibly counterbalance some of the harm caused by mercury exposure. The authors concluded that current methylmercury exposure guidelines based on fish consumption may be inadequate to protect people whose exposure to methylmercury comes from a rice-based diet. They therefore called for more research on the health impacts on pregnant women who are exposed to low doses of methylmercury by eating rice.

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60 Wikipedia entry on the Sami people, http://en.wikipedia.org/wiki/Sami_people.

61 "Critical Review of Mercury Fates and Contamination in the Arctic Tundra Ecosystem," cited above.

62 Hua Zhang et al., "In Inland China, Rice Rather Than Fish Is the Major Pathway for Methylmercury Exposure," *Environmental Health Perspectives*, April 2010, http://ehp03.niehs.nih.gov/article/fetchArticle.action;jsessionid=F7154FD5C22DD646D5200FC587451A05?articleURI=info%3Adoi%2F10.1289%2Fehp.1001915.

The study's authors highlight the urgency of this concern by noting that rice is the main staple food of more than half the world's population. In Asia alone, more than 2 billion people get up to 70 percent of their daily dietary energy from rice and its by-products. The authors therefore conclude that related research should be urgently conducted not only in China but also in other countries and regions that produce a significant percentage of the global rice harvest and where rice is a staple food, such as India, Indonesia, Bangladesh and the Philippines.[63]

63 Ibid.

6. HOW MERCURY GETS INTO THE ENVIRONMENT

Mercury enters the environment in several different ways. Some mercury enters the environment by natural processes such as volcanic eruptions, geothermic activities and the weathering of mercury-containing rocks. Most of the mercury currently in the global environment, however, entered as a result of human activity. Human activities that release mercury into the environment are called anthropogenic sources of mercury. Once mercury is present in the aquatic or terrestrial environment, it can volatilize and reenter the atmosphere.

Anthropogenic sources of mercury fall into one of three broad categories:

- **Intentional sources:** These sources arise when an intentional decision is made to create a product that contains mercury or to operate a process that uses mercury. Examples of products that contain mercury or a mercury compound include fluorescent lamps, some thermometers, batteries and switches, and other similar products. A non-industrial process that uses mercury is small-scale gold mining, in which elemental mercury is used to capture gold from mixtures of crushed rocks, sediments, soils, or other particles. Examples of industrial processes include chemical manufacturing plants that use mercury compounds as catalysts, especially in vinyl chloride monomer production and some chlor-alkali plants that use pools of elemental mercury as a cathode in electrolysis.
- **Unintentional sources:** These sources arise from activities that burn or process fossil fuels, ores, or minerals that contain mercury as an unwanted impurity. Examples include coal-fired power plants, cement kilns, large-scale metal mining and refining, and fossil fuel extraction for coal, oil, oil shale and tar sands. Incinerators and landfills that are used to dispose of mercury-containing end-of-use products and wastes also release mercury into the environment and are categorized by some as unintentional sources.
- **Remobilization activities:** These sources arise from human activities that burn or clear forests or that flood large areas. The biomass and organic surface soils in forests often contain mercury that has fallen out from the air. Burning or clearing forests—especially boreal or tropical forests—releases

large quantities of this mercury back into the air.[64] Large dam projects flood vast areas, and this allows for mercury trapped in biomass and surface soils to become more readily converted into methylmercury and enter the aquatic food chain.[65] Smaller dams that cause fluctuating upstream water levels can also be a problem. Methylmercury can be produced by bacteria that flourish on shorelines that are alternately exposed to air and covered with water as small dams open and close their floodgates.[66]

Researchers have tried to estimate the total amount of mercury released into the environment from different categories of anthropogenic sources. The data available to these researchers, however, is both incomplete and inexact. It is particularly difficult to distinguish between a natural source of mercury (that enters the environment from volcanic activity or the weathering of rocks), and the remobilization and reemission of mercury that originally entered the environment from an anthropogenic source and was subsequently deposited into the water or onto land.

Because of this difficulty, most published estimates of natural sources of mercury in the atmosphere actually include in their totals the reemissions of mercury that had previously entered the environment as a result of human activities.[67] This inflates many of the published estimates of the amount of mercury in the global environment from natural sources, and it unintentionally fosters the impression that the mercury released into the environment by volcanoes and by the weathering of rocks are larger contributors to total global atmospheric mercury than they actually are. If the reemissions of mercury that originally entered the environment as a result of human activities could be counted as contributing to the total of all global atmospheric mercury emissions, then estimates of total anthropogenic mercury emissions into the atmosphere would likely be considerably higher than currently published estimates.

It is also difficult to calculate the percentage of global mercury pollution coming from different anthropogenic sources. The United Nations Environment Programme (UNEP) "Global Mercury Assessment 2013" [68] identifies various human

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64 "Technical Background Report to the Global Atmospheric Mercury Assessment," AMAP and UNEP, 2008, p. 7, http://www.chem.unep.ch/mercury/Atmospheric_Emissions/Technical_background_report.pdf.

65 "James Bay Dam, Electricity, and Impacts," The Global Classroom, American University, http://www1.american.edu/ted/james.htm.

66 Kristen Fountain, "Study Links Mercury to Local Dams, Plants," *Valley News*, 2007, http://www.briloon.org/pub/media/ValleyNews1.10.07.pdf.

67 N. Pirrone et al., "Global Mercury Emissions to the Atmosphere from Anthropogenic and Natural Sources," *Atmospheric Chemistry and Physics*, 2010, http://www.atmos-chem-phys-discuss.net/10/4719/2010/acpd-10-4719-2010-print.pdf.

68 UNEP, (2013) Global Mercury Assessment 2013, Sources, Emissions, Releases and Environmental Transport. UNEP Chemicals Branch, Geneva, Switzerland.

activities that release mercury into the environment and provides emissions data for many of them. This emissions data is frequently cited as an indicator of the proportion of global mercury pollution that comes from these different sources. According to this data, artisanal and small-scale gold mining (ASGM) is the largest source of mercury pollution to air and accounts for 35 percent of all global mercury emissions from anthropogenic sources, and burning fossil fuels—primarily coal—is the second largest source of mercury pollution to air and accounts for an estimated 25 percent of global emissions.[69]

Some estimates of mercury emissions from various sources, however, can be misunderstood. This is because reported atmospheric emissions estimates are based only on measurements of mercury released directly into the air and do not take into account mercury releases into wastes, soils and water even though much of this mercury will subsequently volatilize and enter the air. Nor do these emission estimates take into account other unmeasured mercury releases associated with the source. Actual mercury releases from a source may be much higher than the reported mercury emissions from the source. In its most recent estimates[70] UNEP recognizes many of these data gaps and improves estimates by including mercury releases to water and estimates of releases from diffuse sources. However, there are still some major data gaps in UNEP estimates such as emissions and releases from the Chinese vinyl chloride monomer (VCM) industry (this is discussed in more detail in other sections of this booklet).

69 Ibid.

70 Ibid.

EMISSION ESTIMATE DATA MAY BE MISUNDERSTOOD

The reported percentage of global air emissions that come from a particular source is often used as an indicator of how much of the world's mercury pollution comes from that source. So, for example, when we read that burning fossil fuels accounts for 25 percent of all global mercury air emissions from anthropogenic sources, it is natural to conclude that 25 percent of the global mercury pollution problem comes from burning fossil fuels. But this may be a misleading conclusion for a number of reasons:

- There are some sources of mercury air emissions for which there is little data or no data. The contribution to global mercury air emissions from these sources may be greatly underestimated.
- It is easier to measure the amount of mercury emissions to the atmosphere from some sources than for others. The contribution to global mercury air emissions from hard to measure sources may be underestimated.
- Some mercury sources such as mercury in products have a complicated life cycle. It may be difficult to fully incorporate the mercury air emissions that occur at all points in the product life cycle into the emissions estimates associated with these sources.
- Some mercury sources release large quantities of mercury to soils, water and wastes. Mercury releases to these media do not generally count as contributing to total global air emissions However, mercury that is released to media other than air will frequently contaminate aquatic ecosystems and contribute to total global mercury pollution. Additionally, much of the mercury released to these media will, at a later time, volatilize and enter the air. It may be difficult to fully incorporate such secondary air emissions into global air emissions estimates associated with the original source.

One extreme example of an underestimated source is VCM production. China is the only country that uses a mercury based method for VCM production and there is only scarce available data on mercury air emissions from this source. Therefore, global mercury air emissions from VCM production are counted as zero in UNEP's estimated total anthropogenic mercury emissions to the atmosphere of 1,960 metric tons.[71] And yet, more mercury is used in VCM production than is used in most other intentional sources. A tentative estimate (not included in the total releases) by UNEP is that around 800 metric tons of mercury was used in the VCM industry in China in 2012. If all of this mercury were to re-enter the environment then VCM would outstrip even ASGM (727 metric tons) as the largest source of anthropogenic mercury pollution on current estimates. There are good common sense reasons to assume that VCM production is a major contributor to global mercury pollution. However, if one were to use UNEP's global air emissions estimates as an indicator, one could reach the obviously false conclusion that VCM production contributes zero percent to the world's total mercury pollution.

In an earlier UNEP report (The 2008 UNEP "Global Mercury Assessment") the conclusion that artisanal and small-scale gold mining contributed 18 percent of anthropogenic mercury emissions was based on UNEP estimates that the total of all anthropogenic mercury emissions to the atmosphere was 1,930 metric tons per year and that ASGM activities globally generated 350 metric tons of these mercury emissions. However, the report that provides this data also estimates that ASGM activities consumed 806 metric tons of mercury per year.[72] One must therefore give

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71 Ibid.

72 UNEP, (2008) Global Mercury Assessment 2008: Sources, Emissions, Releases and Environmental Transfers.

consideration to the fate of the rest of the mercury consumed by ASGM activities (the missing 456 metric tons).

A portion of this total may be recovered. (But most mercury recovered in ASGM activities would be reused by miners and would likely not show up in estimates of mercury consumption from the sector). A very large fraction of the 850 tons of mercury consumed by ASGM activities is almost certainly released into the environment. Most of what is not included in the official air emissions estimate is released into water, onto land, into wastes, or is just not accounted for. Much will later be reemitted from the water or land into the air, although it may not all be counted as air emissions. This is why estimates of the portion of global mercury pollution coming from ASGM activities has been revised upwards from 18 percent in UNEP's 2008 assessment to 37 percent in UNEP's 2013 estimates.

In another example, when a battery, a fluorescent bulb, or some other mercury-containing product goes into a dump or landfill, much of its mercury content is released over time to the air and to other environmental media. When burned or incinerated, the mercury content can be released more quickly as it is difficult to capture even with modern filters. Chlor-alkali plants and VCM manufacturing also certainly release much more mercury into the environment than official air emission estimates suggest.

Most of the mercury consumed by intentional sources almost certainly ends up in the environment, and much of it ends up circulating through the global atmosphere. The only way to make sense of the reported data on anthropogenic mercury emissions is to conclude that environmental releases of mercury from intentional sources are a much larger contributor to total global mercury pollution than UNEP's emissions data alone might suggest. Additionally, since much of UNEP's data comes from government sources and reflects the ways most governments gather data on mercury air emissions and other releases to the environment, NGOs would do well to critically examine the mercury emission and release data supplied and used by their national governments.

7. MERCURY SUPPLY

Virtually all products or processes that contain or use mercury or mercury compounds are dependent on access to a supply of elemental mercury.

7.1 MERCURY MINING

Since ancient times, people have mined a naturally occurring red or reddish brown ore called cinnabar, which contains high quantities of mercury sulfide. The first reported large-scale cinnabar mine began operation more than 3,000 years ago in the Peruvian Andes. As far back as 1400 B.C.E., cinnabar ore was excavated from mines near the present day town of Huancavelica, Peru. The ore was crushed to make a red pigment known as vermillion. Cinnabar mining began at the site long before the rise of the Inca civilization and continued into modern times. Vermillion was used by the Incas and other ancient civilizations in the region to cover the human body for ceremonial purposes and also to decorate gold objects such as burial masks.[73] Vermillion produced from cinnabar was also known in ancient China and India. It was used in ancient Rome to color the faces of triumphant generals.[74]

Elemental mercury can be produced from cinnabar by heating the ore in the presence of air and then condensing elemental mercury from the vapor (the chemical equation for the reaction that takes place is HgS + O2 Đ Hg + SO2). Knowledge of this process dates back to at least 200 B.C.E., and ancient Greeks, Romans, Chinese, and Hindus all knew how to produce elemental mercury this way.[75] There is also suggestive evidence that the Incas learned to produce elemental mercury this way before their first contact with Europeans.[76]

The world's largest known reserves of cinnabar ore are located at the Almadén mine in Spain. Mining and refining operations began at that location more than 2,000 years ago. Mercury from the Almadén mine was used by the ancient Phoenicians and Carthaginians and later by the Romans to amalgamate and concen-

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73 John Roach, "Mercury Pollution's Oldest Traces Found in Peru," National Geographic News, May 18, 2009, http://news.nationalgeographic.com/news/2009/05/090518-oldest-pollution-missions.html.

74 Wikipedia entry on vermilion, http://en.wikipedia.org/wiki/Vermilion.

75 "Mercury: Element of the Ancients," Dartmouth Toxic Metals Research Program, http://www.dartmouth.edu/~toxmetal/metals/stories/mercury.html.

76 "Mercury Pollution's Oldest Traces Found in Peru," cited above.

trate gold and silver. The Roman author Pliny was the first to provide a detailed description of this process in his book, *Natural History*.[77]

Data is available on the operations of the Almadén mine and other mines over the past five centuries. Since the year 1500 C.E., approximately one million metric tons of elemental mercury has been produced from cinnabar and other ores mined at Almadén and at other locations. Half that amount—500,000 tons—had already been produced before 1925. Shipments of mercury from Spain for use in silver or gold mining in the Spanish colonies in America continued for 250 years. Most of the mercury went to locations in present day Mexico.[78]

GOLD AND SILVER MINING IN EARLIER CENTURIES

The largest use of mercury during the sixteenth to eighteenth centuries was for the production of silver and gold in Latin America, and this use released enormous quantities of mercury into the global environment. Most of this silver and gold was shipped back to Spain and Portugal, where it became a major contributor to rapid economic expansion in Western Europe.

The nineteenth century saw a large boom of mercury mining in North America for use by gold rush miners in California and then northern Canada and Alaska. This gold production was an important contributor to economic expansion in North America. Nineteenth-century gold booms also occurred in Australia and in other countries. Large quantities of mercury from the gold and silver mining of earlier centuries remain in the environment and continue to be a source of harm.[79,80]

Operations that mine mercury ores and refine them into elemental mercury release a large amount of mercury vapors into the air and are thus also a direct and significant source of mercury pollution. One study found atmospheric mercury concentrations around an abandoned mercury mine in China to be several orders of magnitude higher than regional background sites.[81] A study of human exposure

77 Luis D. deLarcerda, "Mercury from gold and silver mining: a chemical time bomb?" Springer 1998

78 Hylander, L.D. Meili, M., (2003). 500 years of mercury production: global annual inventory by region until 2000 and associated emissions. The Science of The Total Environment 304(1-3): 13-27, http://www.zeromercury.org/library/Reports%20General/0202%20Hg500y_STE03Larsgleobalemissions.pdf.

79 Charles N. Alpers et al., "Mercury Contamination from Historical Gold Mining in California," U.S. Geological Survey fact sheet, 2005, http://pubs.usgs.gov/fs/2005/3014/.

80 B.M. Bycroft et al., "Mercury Contamination of the Lerderberg River, Victoria, Australia, from an Abandoned Gold Field," *Environmental Pollution, Series A, Ecological and Biological*, Volume 28, Issue 2, June 1982.

81 "Mercury Pollution in a Mining Area of Guizhou, China," *Toxicological & Environmental Chemistry*, 1998, http://www.informaworld.com/smpp/content~db=all~content=a902600843.

to mercury from eating rice grown in a district near mercury mines and smelters found high exposure, even when compared with districts near zinc smelters and heavy coal-based industries.[82] Researchers in California measured significant amounts of mercury leaching into a creek flowing past a long-abandoned mercury mine site. This and preliminary results from other mine sites indicate that inoperative mercury mines are major sources of mercury pollution to water bodies, and they also, in turn, remain continuing sources of atmospheric mercury emissions as well.[83]

In recent years, most of the primary mercury mines in the world have closed. The last mercury mine in the United States closed in 1990; a large mercury mine near Idrija, Slovenia, closed in 1995; and the Almadén mine in Spain stopped mining and processing primary mercury ores in 2003. At present, there are no primary mercury mines operating in North America or Western Europe, and none are expected to restart. Most other mercury mines in the world have also closed, including a major mine in Algeria that appears to have stopped operations at the end of 2004.[84,85]

According to the U.S.GS, most primary mercury mining currently takes place in only two countries: China and Kyrgyzstan. In 2012, Chinese mines produced an estimated 1200 metric tons of mercury and Kyrgyz mines produced an estimated 150 metric tons.[86] According to the Chinese Government, mercury exports from China are very low and most of its mercury production is used domestically.[87] The Khaidarkan mining complex in Kyrgyzstan, on the other hand, produces mainly for the export market.[88] The U.S.GS estimates total 2012 mercury mine production in all other countries to be 100 metric tons combined.[89] A recent surge in the

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82 Hua Zhang et al., "In Inland China, Rice Rather Than Fish Is the Major Pathway for Methylmercury Exposure," *Environmental Health Perspectives*, April, 2010, http://ehp03.niehs.nih.gov/article/fetchArticle.action;jsessionid=F7154FD5C22DD646D5200FC587451A05?articleURI=info%3Adoi%2F10.1289%2Fehp.1001915.

83 Tim Stevens, "Inoperative Mercury Mines Fingered as a Major Source of Mercury Contamination in California Waters," *U.C. Santa Cruz Currents*, 2000, http://www.ucsc.edu/currents/00-01/11-06/pollution.html.

84 "500 Years of Mercury Production," cited above.

85 "Summary of Supply, Trade and Demand Information on Mercury," UNEP, 2006, http://www.chem.unep.ch/mercury/HgSupplyTradeDemandJM.pdf.

86 Mercury Statistics and Information, U.S. Geological Survey, 2010, http://minerals.usgs.gov/minerals/pubs/commodity/mercury/mcs-2010-mercu.pdf.

87 "Mercury Situation in China," Chinese government submission to the UNEP Mercury Open-Ended Working Group, http://www.chem.unep.ch/Mercury/OEWG1/China_response.pdf.

88 "Summary of Supply, Trade and Demand," UNEP, cited above.

89 Mercury Statistics and Information, U.S. Geological Survey, cited above.

price of mercury has seen China re-open some mercury mines[90] that were previously considered uneconomical. The surge in the price of mercury has mainly been attributed to the high price of gold and subsequent surge in gold production (and mercury use) as well as high demand for energy efficient Compact Fluorescent Lamps (CFLs) which contain mercury.

7.2 PRODUCING ELEMENTAL MERCURY AS A BY-PRODUCT IN NONFERROUS METALS REFINING

Elemental mercury is also sometimes produced as a by-product when various metal ores are refined. Mercury is found in trace quantities in most nonferrous metal ores such as zinc, copper, lead, gold, silver and others. Until recently, the mercury content of these ores would be released into the environment as part of the waste streams generated during mining and refining. In recent years, however, some refiners have started to recover mercury from their wastes and produce elemental mercury for sale on domestic or international markets. [91]

Many producers who have decided to do this have been required to do so in order to comply with national, state, or provincial laws or regulations. In other cases, producers may be required to comply with laws or regulations governing mercury waste disposal, and may have determined that it is less costly to recover elemental mercury from their wastes and sell it than it would be to dispose of their mercury wastes in compliance with approved disposal methods.

For example, approximately 35 pollution-control systems that remove mercury from zinc smelter flue gases are now in operation worldwide.[92] A handful of large-scale gold mining operations in South America and North America recover elemental mercury from their wastes and sell this mercury. According to one very cautious estimate, approximately 300 to 400 metric tons of mercury was recovered globally in 2005 by refiners of zinc, gold, copper, lead and silver.[93] This estimate does not include a large contract between the Russian Federation and the Khaidarkan mercury mining and refining facility in Kyrgyzstan. Under this contract, existing stockpiles of mercury-contaminated wastes from a large zinc smelter and other Russian sources are to be transported to Kyrgyzstan for refining. It has been estimated that approximately 2,000 metric tons of elemental mercury are to be extracted from these wastes and then sold.[94]

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90 Hu, Fox Yi., (2012) *South China Morning Post* 'Toxic mercury mines reopen as price soars' Friday, 30 March, 2012.

91 "Summary of Supply, Trade and Demand," UNEP, cited above.

92 Ibid.

93 Ibid.

94 Ibid.

7.3 ELEMENTAL MERCURY FROM NATURAL GAS

Natural gas also contains trace quantities of mercury that is released into the environment when the gas is burned. In some areas—including countries bordering the North Sea, Algeria, Croatia, and others—the mercury concentrations in the gas are particularly high and processors in these areas often remove mercury from their gas. It is estimated that 20–30 metric tons of mercury are recovered yearly from natural gas wastes in the European Union.[95] Data does not appear to be available on mercury recovered from natural gas in other regions although one estimate suggests that around 10 metric tons of elemental mercury may be recovered from global gas production outside of the European Union.[96]

Producers of liquid natural gas (LNG) remove mercury from natural gas before cooling it. Otherwise, the mercury present in the gas will damage the aluminum heat exchangers used in natural gas liquefaction plants. This typically requires reducing the mercury content of the natural gas to below 0.01 micrograms of mercury per normal cubic meter of natural gas. Based on a review of marketing materials from manufacturers of equipment to remove mercury from natural gas, it appears that the main reason this equipment is purchased is to protect the downstream equipment of liquefaction and chemical production plants. Outside of Western Europe, it appears these technologies are not widely used to remove mercury from natural gas sold for use in residential heating and cooking or commercial and industrial furnaces and boilers.[97] Little is known about the effects of this mercury on ordinary natural gas consumers or its contribution to total global atmospheric mercury pollution.

One supplier of equipment to remove mercury from natural gas to protect liquefaction equipment suggests that in its recent analytical experience, mercury levels in natural gas have ranged from less than detectable to 120 micrograms of mercury per normal cubic meter. The supplier provides a typical case example from a facility at an unnamed location, but one clearly outside the European Union. At this facility, the incoming gas mercury content ranged from 25 micrograms to 50 micrograms of mercury per normal cubic meter of natural gas while the mercury content in the outgoing gas was reduced to below detection limits. The mercury is removed from the natural gas with proprietary adsorbents. The adsorbents are then regenerated, and elemental mercury is removed in what the technology

95 Ibid.

96 Concorde East West (2006) Mercury flows and safe storage of surplus mercury. Commissioned by the Environment Directorate-General of the Commission of the European Communities. page 12.

97 Giacomo Corvini et al., "Mercury Removal from Natural Gas and Liquid Streams," UOP LLC, http://www.uop.com/objects/87MercuryRemoval.pdf.

company claims is a form that can be sold on the market.[98] However, outside of Western Europe, salable elemental mercury that is recovered by these technologies does not appear to be reflected in internationally available mercury-supply data.

7.4 MERCURY RECYCLING AND RECOVERY

Most of the elemental mercury that is recovered by recycling comes from industrial processes that use mercury or mercury compounds. In some cases, the mercury that is recovered is reused by the industry. In other cases, it goes onto the market. And in some instances, agreements have been reached to remove the recovered mercury from the market and place it in permanent storage.

The largest source of recycled or recovered mercury is the chlor-alkali industry. This industry produces chlorine gas and alkali (sodium hydroxide) by a process that applies electrolysis to saltwater. Some chlor-alkali plants use a mercury-cell process in which mercury is used as the electrolysis cathode.[99] Mercury-cell chlor-alkali plants consume large quantities of mercury and are very polluting. Fortunately, the trend in recent years has been to phase out many of these mercury-cell plants in favor of other processes that do not use mercury.

A single mercury-cell plant may contain hundreds of tons of elemental mercury for use in production and may have even more mercury in its warehouses to replenish lost mercury. When a mercury cell is decommissioned, much of this mercury can be recovered. Under a voluntary agreement, mercury-cell chlor-alkali plants in Western Europe are being slowly phased out with an agreed-upon completion date of 2020. A 2004 study that examined closures of European chlor-alkali mercury cells concluded that between 1980 and 2000, nearly 6,000 tons of mercury was recovered from decommissioned mercury cells. The study estimated that in 2004, approximately 25,000 tons of mercury inventories were associated with then-operating chlor-alkali plants, about half of them in Western Europe.[100] In April 2010, a European industry association stated that there were 39 mercury-cell chlor-alkali plants still operating in 14 European countries which, taken together, contain 8,200 metric tons of elemental mercury.[101]

98 Ibid.

99 A description of this process can be found at http://en.wikipedia.org/wiki/Castner-Kellner_process.

100 "Mercury Flows in Europe and the World: The Impact of Decommissioned Chlor-Alkali Plants," European Commission

Directorate General for Environment, 2004, http://ec.europa.eu/environment/chemicals/mercury/pdf/report.pdf.

101 "Storage of Mercury: Euro Chlor View," Euro Chlor, April, 2010, http://www.eurochlor.org/news/detail/index.asp?id=325&npage=1&archive=1.

Further mercury-cell chlor-alkali plant closures or conversions to mercury-free processes can be expected in the next decade. The World Chlorine Council estimates that the number of chlor-alkali plants using mercury electrolysis units in USA, Canada, Mexico, Europe, Russia, India, Brazil, Argentina and Uruguay has fallen from 91 plants in 2002 to 50 plants in 2012.[102]

Operating mercury-cell chlor-alkali plants also sometimes recover mercury from their waste streams. It is estimated that in 2005, worldwide, between 90 and 140 metric tons of mercury were recovered from operating mercury-cell chlor-alkali plants.[103]

The other type of manufacturing that uses and recycles large quantities of mercury is the production of VCM to produce polyvinyl chloride (PVC), in which mercuric chloride is used as a catalyst. This process is not used in most countries. However, four such facilities are believed to be operating in the Russian Federation, and more than 60 are operating in China. It is not known whether similar facilities are operating in other countries.[104]

In the Chinese plants, the catalysts used in one year are estimated to contain 610 metric tons of mercury. In 2004, the industry estimated it recycled nearly half of the mercury originally contained in its catalysts (290 tons), but it provided no information on the fate of the other half.[105] In 2005 the Chinese VCM industry consumed 700-800 metric tons of mercury with similar recovery rates to 2004. The rate of growth of mercury use in this industry has been estimated at 25-30 percent per annum although this may be affected by economic growth rates over time. The mercury that is not recovered in VCM processes is combined with hydrochloric acid (HCl) by-product and is not recovered[106]. The eventual fate of this mercury is not clear.

Elemental mercury can be recovered by properly managing mercury-containing products at the end of their life, such as mercury-containing thermometers, dental amalgam, switches, fluorescent lamps and other similar items. It can also be recovered from mercury-contaminated wastes generated at plants that manufacture

102 World Chlorine Council (2013) World Chlorine Council Report to UNEP on Chlor-Alkali Partnership - Data 2012

103 "Summary of Supply, Trade and Demand Information on Mercury, " UNEP, 2006, p. 32, http://www.chem.unep.ch/mercury/HgSupplyTradeDemandJM.pdf.

104 Ibid.

105 Ibid.

106 ACAP (2005) – "Assessment of Mercury Releases from the Russian Federation." Arctic Council Action Plan to Eliminate Pollution of the Arctic (ACAP), Russian Federal Service for Environmental, Technological and Atomic Supervision & Danish Environmental Protection Agency. Danish EPA, Copenhagen. See http://www.mst.dk/udgiv/Publications/2005/87-7614-539-5/html/helepubl_eng.htm

mercury-containing products, use mercury in their production processes, or burn or process mercury-contaminated fuels or minerals.

7.5 THE NEED TO REDUCE MERCURY SUPPLY

Between 1991 and 2003, the price of mercury stabilized at its lowest real level in a century, to between U.S.D 4 and 5 per kilogram.[107] More recently, mercury prices have dramatically gone up. At the time of this writing, the spot price for a flask of mercury on the London market is between U.S.D 3,000 and 3,300.[108] This translates into a price per kilo of mercury of between U.S.D 86 and 95, which is a significant increase over recent low prices. The rise may reflect a reduction in mercury supply based on mercury mine closures and actions by some governments to restrict mercury exports. It may reflect an increase in mercury demand by artisanal and small-scale gold miners as the price of gold rises to new heights. Some analysts have attributed the rise, in part, to the phase out of incandescent light globes and their replacement with CFL globes containing mercury. Demand for CFL light globes has been very high with China tripling production between 2001 and 2006 to 2.4 billion units.[109] China produces around 85 percent of global CFLs and is a net importer of mercury. It may also reflect hoarding by mercury traders who anticipate that a global mercury-control treaty will soon be adopted that will restrict future mercury supplies. Most likely, all of the above factors are at play.

High mercury prices will discourage some uses of mercury and will make it easier to implement substitutes and alternatives that eliminate or minimize the use of mercury. Therefore, the objectives of the mercury treaty are best served if the mercury price is high enough to discourage mercury demand. However, some features of mercury-control regimes could have the consequence of creating new or expanded sources of mercury. As governments impose stricter controls on mercury emissions and on the disposal of mercury-contaminated products and wastes, it creates incentives for metals refiners, recyclers and others to recover elemental mercury from waste streams and fossil fuels and to bring this newly recovered mercury onto the market. At the same time, a global mercury-control treaty may also contribute to decreased global mercury demand by eliminating, phasing out, or reducing numerous current uses of mercury. Finally, although there may currently be some hoarding of mercury stocks by traders in anticipation of future supply shortages, this is likely no more than a short-term phenomenon. For these reasons, mercury prices could again fall in the absence of specific interventions

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107 "Summary of Supply, Trade and Demand Information on Mercury," UNEP, cited above.

108 Minor Metal Prices, MinorMetals.com, December 2013, http://www.minormetals.com.

109 "Strong Growth in Compact Fluorescent Bulbs Reduces Electricity Demand." Worldwatch Institute http://www.worldwatch.org/node/5920

to ensure that the global mercury supply is and remains restricted relative to the global demand.

To help address this, the European Union has adopted a regulation that entered into force in March 2011. This regulation bans exports from the E.U. of metallic mercury, cinnabar ore, mercury chloride, mercury oxide and mixtures of metallic mercury with other substances. The regulation also bans the primary production of elemental mercury from cinnabar ores in all E.U. countries. It additionally classifies as waste all metallic mercury recovered from mercury-cell chlor-alkali plants as well as mercury obtained from nonferrous mining and smelting operations and the cleaning of natural gas. The classification of this mercury as waste means that mercury derived from these sources in E.U. countries cannot be sold or used but must be disposed of in a way that is safe for human health and the environment.[110]

The United States has also passed a law that addresses mercury exports. This law became effective in January 2013. It prohibits, with some exceptions, exports of elemental mercury from the U.S., and it requires the establishment of a designated facility for the long-term management and storage of mercury generated within the United States.[111]

These actions by the E.U. and the U.S. go in a very positive direction. Some aspects of the E.U. and U.S. restrictions are picked up in Article 3 of the mercury treaty dealing with mercury supply sources and trade. Unfortunately many aspects of this article are relatively weak, permitting long phase-out periods for primary mercury mining and allowing mercury to be traded to countries with an ASGM sector. However, mercury arising from closure of chlor-alkali plants may be regulated more effectively and disposed of according to Treaty requirements that may prevent it from entering a new trade cycle.

It also has to be acknowledged that a significant quantity of mercury is traded and supplied in such a manner as to avoid detection at some point in the supply chain. There is clear evidence that large quantities of elemental mercury have been smuggled into certain countries where ASGM is practiced and where restrictions on mercury use apply. The mercury may have entered the supply chain legally and been transported legally up to a certain point before entering a country without being detected by authorities. This issue is discussed in greater detail in section 9.1 of this booklet.

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110 Regulation (EC) No. 1102/2008 of the European Parliament and of the Council of 22 October 2008 on the banning of exports of metallic mercury and certain mercury compounds and mixtures and the safe storage of metallic mercury; http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:304:0075:01:EN:HTML.

111 "Mercury Export Ban Act of 2008," Global Legal Information Network, http://www.glin.gov/view.action?glinID=71491.

Article 3 Mercury supply sources and trade

- New primary mining is banned as of the entry into force by a government. However, a government may permit new mercury mines before then and if a government postpones ratification, then it has a longer window of time for developing new mines.
- Pre-existing primary mercury mining is banned after 15 years as of date of entry into force for a government. If a government postpones ratification, then it can mine mercury from pre-existing mines for a longer period.
- Mercury from primary mining after ratification can only be used for making permitted products or used in permitted processes (such as VCM, etc., described below in Articles 4 and 5), or disposed according to treaty requirements. This implies that mercury from primary mining shall not be available for use in ASGM once a country ratifies the treaty.
- Identifying stocks of mercury greater than 50 metric tons is optional but countries "shall endeavor" to do it. This paragraph is actually linked to Article 10 regarding Interim Storage. Note: this paragraph could also be relevant for identifying ASGM activities within a country since stocks greater than 10 metric tons may signal ASGM activity. Parties could make identification of stocks more comprehensive and useful by including information about the annual capacity of the interim storage/stocks facility, explaining what the stocks are for and plans for them in the future.
- Since ASGM is an allowed use, trade of mercury for ASGM is allowed. However, countries that have already prohibited the use of mercury in mining and ASGM should strengthen their commitment to prohibiting trade of mercury for this use as well.
- Countries are required to "take measures" to ensure that when a chlor-alkali plant closes, the excess mercury is disposed of according to treaty requirements and not subject to recovery, recycling, reclamation, direct re-use, or alternative uses. This is good because it should prevent this mercury from re-entering the market. However, good mechanisms are still needed to ensure this. Note: countries are to take measures to ensure that these wastes are treated in an environmentally sound manner according to Article 11 and future guidelines developed by the Conference of the Parties and added to the treaty.
- Trade of mercury, including recycled mercury from non-ferrous metal smelting and mercury-containing products, is permitted if it is for an "allowed use" under the treaty.

- The treaty contains a "prior informed consent" procedure for mercury trade that requires the importing country to provide the exporting party with its written consent to the import and then to ensure that the mercury is only used for the allowed uses under the treaty or for interim storage.
- A public register maintained by the Secretariat will contain consent notifications.
- If a non-party exports mercury to a party, it has to certify that it is not from prohibited sources.
- The article does not apply to trade of "naturally occurring trace quantities of mercury or mercury compounds" in mining ores, coal, or "unintentional trace quantities" in chemical products or any mercury-containing product.
- The COP can later evaluate if trade in specific mercury compounds is undermining the objective of the treaty and decide if a specific mercury compound should be added to the article.
- Each Party has to report to the Secretariat (Article 21), showing that it has complied with the requirements of this article.

Using the mercury treaty to campaign on supply and trade of mercury

Monitoring Prior Informed Consent (PIC) documentation

There are a number of approaches that NGOs may take to address mercury supply and trade issues in their country under Article 3 of the mercury treaty. A key element of Article 3 is the 'prior informed consent' mechanism mentioned above whereby written assent to any mercury import must be provided to the exporting country by the importing country.

This step will create a publicly accessible database on mercury imports including volume and (potentially) intended use. NGOs can access this data via the mercury treaty Secretariat and analyze how much mercury is entering the country combined with data on existing stocks.

PIC and ASGM

This data may give an indication as to whether ASGM is taking place at more than 'insignificant' levels in the country of import. Stockpiles greater than 10 metric tons may signal ASGM activity, so the 'prior informed consent' data can be a valuable tool to convince media, regulators and politicians that action must be taken on ASGM. Once a country identifies a 'significant' amount of domestic ASGM activity, it is required to develop a National Action Plan and submit it to the Secretariat by three years after entry into force of the mercury treaty. The information can also assist NGOs to identify key players in the mercury trade in their country and identify whether mercury imports may be destined for other uses not permitted under the mercury treaty.

Promoting ratification

NGOs should also campaign to ensure that their government ratifies the mercury treaty as soon as possible to start the clock ticking on time limits for primary mercury production and restrictions on mercury stockpiles arising from chlor-alkali plant closures. There are no provisions in the mercury treaty to prevent a country from unilaterally banning exports or imports of mercury at any time in advance of ratification of the Treaty or prohibiting the use of mercury in activities such as ASGM (as has been the case in some parts of Indonesia, Malaysia and the Philippines). In this sense NGOs are free to campaign for their governments to impose such prohibitions without waiting for national ratification of the mercury treaty.

Establish interim storage to secure mercury

Another key element in controlling and reducing the mercury trade is the preparedness of individual countries to establish storage and/or disposal infrastructure for mercury that are compliant with the terms of the mercury treaty. As a priority NGOs should work with and encourage their national governments to establish mercury storage and/or disposal facilities that are capable of safely securing excess mercury. This is important as it provides an appropriate and secure destination for mercury arising from seizure of illegal stockpiles or imports, surplus mercury from closure of chlor-alkali facilities, mercury arising from remediation of contaminated sites, wastes and mercury stripped from mining and gas refining that is not destined for an approved use. Without secure and environmentally sound storage capacity it will be very difficult for countries to prevent mercury from re-entering the global supply chain.

The closure and conversion of chlor-alkali plants from mercury cell processes has been identified as a major source of mercury entering the global supply chain. NGOs can monitor the operation of mercury based chlor-alkali plants in their countries and campaign for their closure or conversion to mercury free processes. The termination of mercury based processes at a chlor-alkali plant can generate hundreds of metric tons of metallic mercury from the obsolete cells and the inventories of mercury stored at the plant that are regularly used to replenish the cells.

The mercury treaty prohibits any re-use of the mercury arising from chlor-alkali plant closures and NGOs can play a key role in ensuring that this mercury waste is directed to appropriate storage and disposal. Having appropriate storage and disposal infrastructure in place *before* plant closure is essential to prevent the mercury from re-entering the supply chain. If possible NGOs should also attempt to ascertain the annual volumes of mercury in cells and under inventory at individual facilities *prior* to their closure and ensure that this data is consistent with the amount of mercury sent to disposal and storage following the plant closure.

Identify domestic sources of mercury that can be directed to storage

NGOs should also consider establishing dialogue with industry associations representing scrap metal recyclers, automotive wreckers, CFL lamp recyclers, non-ferrous metal refiners and other market sectors where significant volumes of mercury may be recovered. NGOs can seek voluntary commitments from these industries to direct any mercury recovered to storage and disposal instead of reselling them into the supply chain.

8. INTENTIONAL SOURCES: MERCURY IN PRODUCTS

A number of common products contain mercury or mercury compounds. During the manufacture of these products, mercury is often released into the air (both inside and outside the workplace) and is also often released as a contaminant in solid and liquid waste streams. During their ordinary use, mercury-containing products often break or otherwise release their mercury content into the environment. At the end of their useful life, only a fraction of all mercury-containing products goes to recyclers that recover their mercury content. Frequently, these end-of-life products go to incinerators, landfills, or dumps. Depending on the air pollution control measures that are used, incinerators can rapidly release the mercury content of end-of-life products into the air. Landfills and waste dumps also release much of the mercury content of these products into the air, water and soil, but tend to do so a little more slowly. In one way or another, much of the mercury content of products eventually finds its way into the environment.

The hazards associated with mercury added products cannot be underestimated. The potential for mercury to be released at every stage from manufacture through useful life and disposal phase means that the potential for exposure during daily use of these products is high. The solution is to phase down and phase out these products as quickly as mercury free alternatives become available. In most instances the alternatives already exist but experience barriers to entry into the marketplace for a range of reasons. In some cases local laws, insurance policies or other regulations require the specific use of a product that contains mercury. In some cases the barriers may be cultural or religious. In other circumstances the large market share of mercury-added products makes them inexpensive compared to mercury free alternatives that may be new to the market. Most of these barriers can be relatively easily overcome if the public and governments are informed about the hazards of mercury added products and their cost to society in terms of human health impacts and environmental damage.

What does the Mercury Treaty say about mercury added products?

The mercury treaty contains provisions under Article 4 that will eventually ban the manufacture, import and export of mercury-added products by Parties. While the mechanism of the phase-out is most likely to be in the form of national legislation mirroring the intent of Article 4, the treaty itself uses the phrase “taking appropriate measures” when referring to actions required of Parties. A list of products (Annex A of the mercury treaty) that will be subject to these requirements has been created. This list is subject to review and the addition of further products five years after the treaty enters into force.

The timing of these phase-outs is dependent on whether some Parties seek exemptions under Article 6 of up to 5 years with an option to seek further exemptions for up to 10 years, meaning the phase out will be effective only in 2030.

A modified approach has been taken with dental amalgam which is subject to a 'phase-down' under the mercury treaty with Parties given a list of alternatives to adopt dependent on the domestic situation. More detail is provided below in IPEN's summary of Article 4.

Certain mercury-added products are excluded altogether from the provisions of Article 4 including:

- Vaccines containing thiomersal.
- Military products.
- Products essential for civil protection.
- Products relating to religious and traditional practices.
- Switches and relays.
- Some forms of electronic displays.

Article 4 Mercury-added products

- Product prohibition occurs by "taking appropriate measures" to "not allow" the manufacture, import, or export of new mercury-containing products. Note: the sale of existing stocks is permitted.
- The treaty uses a so-called 'positive list' approach. This means that the products to be phased out are listed in the treaty; the treaty does not address others.
- Parties are to discourage the manufacture and distribution in commerce of new mercury-added products before the treaty enters into force for them unless they find that a risk and benefits analysis shows environmental or human health benefits. These 'loophole' products are to be reported to the Secretariat, which will make the information publicly available.
- There is a list of products that are scheduled for phasing out by 2020. However (see Article 6), countries can apply for a five-year exemption to the phase-out date and this can be renewed for a total of 10 years, making the effective phase-out date for a product, 2030.

- Products to be phased out by 2020 include batteries (except for button zinc silver oxide batteries with a mercury content < 2 percent, button zinc air batteries with a mercury content < 2 percent); most switches and relays; CFL bulbs equal to or less than 30 watts containing more than 5 mg mercury per bulb (an unusually high amount); linear fluorescent bulbs - triband lamps less than 60 watts and containing greater than 5 mg mercury and halophosphate lamps less than 40 watts and containing greater than 10 mg mercury; high pressure mercury vapor lamps; mercury in a variety of cold cathode fluorescent lamps (CCFL) and external electrode fluorescent lamps (EEFL); cosmetics including skin lightening products with mercury above 1 ppm except mascara and other eye area cosmetics (because the treaty claims that no effective safe substitute alternatives are available); pesticides, biocides, and topic antiseptics; and non-electronic devices such as barometers, hygrometers, manometers, thermometers, and sphygmomanometers (to measure blood pressure).
- A product to be "phased-down" is dental amalgam and countries are supposed to pick two measures from a list of nine possibilities taking into account "the Party's domestic circumstances and relevant international guidance." The possible actions include picking two items from a list that includes establishing prevention programs to minimize the need for fillings, promoting use of cost-effective and clinically effective mercury-free alternatives, discouraging insurance programs that favor mercury amalgam over mercury-free alternatives, and restricting the use of amalgam to its encapsulated form.
- Products excluded from treaty include products essential for civil protection and military uses; products for research and calibration of instruments for use as a reference standard; switches and relays, CCFL and EEFL for electronic displays, and measuring devices, if no mercury-free alternative available; products used in traditional or religious practices; vaccines containing thiomersal as preservatives (also known as thimerosal); and mercury in mascara and other eye area cosmetics (as noted above).
- Note: some products listed for prohibition in previous drafts such as paints were excluded during the negotiation process.
- Secretariat will receive information from Parties on mercury-added products and make the information publicly available along with any other relevant information.
- Parties can propose additional products to be phased-out including information on technical and economic feasibility and environmental and health risks and benefits.

- The list of prohibited products will be reviewed by the COP five years after the treaty enters into force; this could be approximately 2023.

How can NGOs use the treaty to campaign for the removal of mercury added products from the market?

The mercury treaty clearly identifies the products that contain mercury. Many are scheduled for phase-down and phase-out and some are exempt. The 'positive list' approach (where listed products are subject to the treaty) provides an opportunity for NGOs to campaign for the accelerated phase out of listed products in their country and to campaign to have their country propose currently *exempted products* for addition to the treaty list at future COP meetings. NGOs can also play a decisive role in raising awareness about the hazards of mercury added products and the benefits of mercury free products, thereby breaking down cultural, political and economic barriers to acceptance of alternatives in their country. A cautionary note also applies in that some mercury free alternatives may present other hazards to human health and the environment. NGOs should endeavor to fully assess any alternative products to ensure they are not substituting one product for another that is equally or more hazardous. This includes a full life-cycle assessment of mercury free products to ensure that there are not 'hidden' hazards during the extraction, manufacture and disposal phase.

Taking action to ensure mercury-added products are rapidly phased-out

NGOs have a range of opportunities under Article 4 of the mercury treaty to ensure that mercury-added products are phased out as soon as possible. It is also important to recognize that not all mercury-added products will be treated the same way. The different approaches to mercury-added products under the mercury treaty are:

- 'Phase-out' of products listed in Annex A of the mercury treaty by 2020.
- 'Phase-down' of dental amalgam which has a range of alternative products and measures under the mercury treaty.
- 'Exemption' of certain products from the requirements of Article 4.
- 'Proposed' additions of mercury-added products to Annex A (new candidate products can be proposed five years after the Mercury treaty enters into force around 2023).
- 'Loophole' products that are new types of mercury-added products that may be developed and released onto the market before the mercury treaty enters into force. (This activity is to be 'discouraged' under the mercury treaty unless risk and benefits analysis shows environmental or human health benefits.).

Taking Action on products subject to 'phase-out'

A critical activity that NGOs can undertake with these products is to ensure that the phase-out time frame is accelerated as fast as possible. The mercury treaty allows exemption time frames of around fifteen years if a country chooses to fully exploit the exemptions available under Article 6 of the mercury treaty for Annex A listed mercury-added products.

As the Annex A list has already been made public, NGOs can raise public awareness, demand mercury content disclosure and warning labels and highlight the damage caused by the mercury in these products in their current campaigns. Activities such as campaigns for boycotts on certain products as well as X-ray Fluorescence device (XRF) or laboratory testing of mercury-added products for media campaigns can build pressure on companies and national governments to develop policies to phase-out these products sooner than required under the mercury treaty. NGOs can also campaign for 'no exemptions' if their governments shows signs of dragging out the phase-out process.

Positive campaigning can also help and NGOs should consider highlighting alternatives to the mercury-added products such as digital fever thermometers for the home instead of mercury thermometers or replacing CFLs with light emitting diode (LED) lighting.

Government agencies may be prepared to collaborate on these schemes and hold coordinated area-based collection days for mercury-added products in conjunction with NGO groups that can also promote mercury-free alternatives. This raises awareness of the hazards of mercury-added products in the community and can remove a significant amount of mercury from homes, schools and businesses. Attention should be paid to ensuring adequate safety measures for these activities in the event that a mercury-added product is broken during the collection. These collection days have been very successful in many countries when dealing with e-waste and household hazardous waste (paints, solvents, acids, chlorine etc.). In addition to the other benefits these collection schemes remove mercury from the general waste stream where it may end up in a landfill or incinerator, which disperse mercury into the environment.

It is important to ensure that any collection scheme is supported by adequate interim storage, recycling, reclamation or disposal infrastructure to prevent the mercury-added products from causing potential contamination.

Taking Action on products subject to 'phase-down'

Dental amalgam is a controversial material due to its hazardous mercury content. Some dentists have argued for its retention as it is inexpensive and versatile however there is also an international consensus on the risk associated with placing a neurotoxic compound in a person's mouth that can release mercury into their body for decades. There is also a clear case to remove the occupational health and safety risks for dental practitioners, given many recorded cases of high mercury vapor levels in dental care settings and ongoing exposure for dental workers and patients. The U.S. government has also recognized that mercury in dental amalgam may also represent a significant risk to unborn children (if the mother has amalgam fillings) and the moral dilemma of imposing a significant health risk on children through amalgam fillings when they are not in a position to make choices or refuse it.

In addition to the personal impact of mercury amalgam on a dental patient there is also a significant environmental impact with its use. One report estimates up to 40 percent of all mercury entering municipal wastewater treatment plants in the U.S. originates from dentists offices[112]. There are also major airborne emissions of mercury from crematoria when bodies are cremated due to the volatilization of mercury vapor from amalgam fillings. Some estimates suggests crematoria mercury releases will be the greatest airborne source of mercury pollution by 2020 with up to 7,700kg in the U.S. alone[113].

The phase-down of dental amalgam is intended as the precursor to a complete phase-out of this product in years to come. Many countries such as Sweden, Norway and Denmark have voluntarily arrived at a decision to essentially ban mercury amalgam.

NGO groups can publicly campaign to phase-out mercury amalgam as soon as possible from either a personal health perspective or an environmental perspective depending on their group's orientation. NGOs can also form alliances with groups seeking mercury-free health care settings (by replacing thermometers, sphygmomanometers and other mercury-added medical products with mercury-free alternatives). Often dental care offices are co-located with other health services and joint campaigns to create a 'mercury-free health center' can be effective.

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112 Association of Metropolitan Sewerage Agencies, "Mercury Pollution Prevention Program, Draft Report," submitted by Larry Walker Associates, 2001.

113 Bender, Michael, "Testimony to the Domestic Policy Subcommittee of the Oversight and Government Reform Committee Hearing on 'Assessing EPA's Efforts to Measure and Reduce Mercury Pollution from Dentist Offices' ", Mercury Policy Project/Tides Center, May 26, 2010, 8 pages

NGOs can also raise public awareness of inexpensive dental alternatives to counter arguments that amalgam is the only cheap solution for developing countries. A progressive form of treatment known as Atraumatic Restorative Treatment (ART) has proven to be very effective for basic caries on two levels. Firstly, the technique involves no drilling or anesthesia, is less invasive and less painful than traditional drill and fill techniques using amalgam. It involves manual excavation of the decayed area and leaves far more tooth material intact than the more destructive drilling technique that can lead to more problems in time. Secondly, you don't have to be a qualified dentist to use the technique, which can be conducted by trained dental hygienists and dental assistants. This makes the treatment far more accessible in developing countries where there may be a shortage of qualified dentists (particularly in remote or rural areas) and significantly reduces the cost of treatment. ART has been endorsed by the WHO and is used in 25 countries.

Any action that NGOs can undertake to increase public awareness of the hazards of dental amalgam will be positive since consumer choice is a key aspect of phase-out of amalgam. Given the opportunity to choose between similarly priced dental alternatives, few patients or parents of patients will opt for amalgam fillings if they are fully informed of the consequences of mercury amalgam. Consumer choice can send a dramatic market signal to dentists if they refuse to accept mercury amalgam fillings.

NGOs should also lobby government to ensure that dental health insurance schemes do not favor dental amalgam. This form of insurance serves to perpetuate the use of mercury in dentistry and acts against the current global push to phase down this product.

Taking action on 'Exempted' and 'Proposed' mercury added products

There are a number of mercury-added products that are excluded from the phase-out requirements of the mercury treaty. These include some eye cosmetics such as mascara, thiomersal in vaccines and 'essential' military and civil defense equipment. There is also a range of scientific instruments used for calibration purposes. CFLs also avoid the phase out if they contain less than 5mg of mercury per bulb. Only a small fraction of mercury bulbs contain more than 5mg of mercury. This is a major pollution issue as billions of CFLs are manufactured each year creating a significant demand for mercury as well as distributing large volumes of it (when total units are considered) back into the community where widespread exposures can occur when lamps are broken, disposed of in an environmentally unsound manner or recycled for glass without adequate worker protection.

NGOs can take action to deal with exempted products on a case by case basis by identifying those products (currently exempted) which present the greatest risk to human health and the environment, ensuring adequate and truthful product labeling information, highlighting alternatives and campaigning to have those high risk products added to Annex A of the mercury treaty. As mentioned earlier, Annex A will be reviewed no later than five years after the mercury treaty enters into force. While this delay unfortunately allows more mercury-added products into society it also allows time to develop alternative mercury-free products. One of the factors taken into consideration in developing the Annex A phase-out list has been the availability of cost-effective mercury-free alternatives for a given product. In some cases it will take time to develop these alternatives or to build sufficient market share to lower the costs. NGOs can track the latest developments for such technology and help make the case that viable alternatives are available and press for listing of exempted products under Annex A. See example below.

The case of CFLs and LED lighting

An example of the rapid change in technology that can assist NGOs in campaigning for mercury-free products is the case of CFLs and LED lighting. In the last decade CFL bulbs have been promoted as an environmentally friendly alternative to incandescent bulbs that have been in widespread service in domestic and commercial lighting in one form or another for around a century. The argument is that CFL bulbs are significantly more efficient in terms of energy use than incandescent bulbs and last a lot longer making them relatively cheap and efficient by comparison. Therefore if CFLs replace incandescent bulbs in most applications there will a large reduction in energy demand and therefore less greenhouse gas (GHG) emissions created at the fossil fuel based power station. In addition this reduces the amount of mercury that would otherwise have been emitted had that coal been burned for energy. This is largely an accurate assumption. Sixty watt (equivalent) CFL bulbs last approximately 20,000 hours using 767 KWh/yr compared to an equivalent, incandescent bulb life of 1,000 hours using 3285 KWh/yr, From the point of view of climate change mitigation and cost the CFL appears to be a reasonable option.

However CFL bulbs contain significant quantities of mercury (1mg-5mg or more), which is released to the environment when the bulb is broken, discarded among regular trash, disposed of in landfill or incinerated. Given that China alone produces over 3 billion CFL bulbs per year the total volume of mercury distributed in society is clearly very high leading to significant environmental contamination and health risks.

A third alternative that is both low in energy consumption and mercury-free has previously been sidelined from the debate due to its expense. The Light Emitting Diode (LED) bulb (60 watt equivalent) lasts 50,000 hours, uses 329 KWh/yr and is mercury free. However LED bulbs have been very expensive in the past with individual units costing between U.S.D 30-50. However, consumers have recognized that LEDs rarely need replacement and dramatically lower running costs, offsetting the initial purchase price. The low energy use and mercury-free status has also increased their popularity. As demand has risen, production volumes have grown bringing down the unit price of domestic LEDs to U.S.D 3-4. Though currently slightly more expensive than comparable CFL units, the price is likely to continue to fall as market share increases.

LIGHTING EFFICIENCY – INCANDESCENT, CFLS AND LEDS[114]

Lighting technology (60 watt equivalent)	Lifespan	Energy consumption/ efficacy	Cost
Incandescent	1,000 hours	3285 KWh/yr (<12 lm/W)	low
CFL	20,000 hours	767 KWh/yr (<70 lm/W).	low
LED	50,000 hours	329 KWh/yr (<120 lm/W).	low

During the long negotiations leading up to the establishment of the mercury treaty the price of LED lighting for domestic purposes has fallen 10 fold making them a viable and 'green' alternative to CFLs. A campaign for increased use of LEDs, especially by government-funded facilities in line with green procurement policy, will further drive the price down. However the relatively high price only a couple of years ago would have discouraged negotiating groups for the mercury treaty from presenting them as an alternative. However NGOs could now consider campaigning to add all mercury-added CFLs to Annex A of the mercury treaty since cost effective LED alternatives are now available. In the same way NGOs can track other products currently exempt from the treaty requirements and propose they be assessed as an addition to Annex A.

114 Data for table compiled from UNEP (2012) Achieving the Global Transition to Energy Efficient Lighting Toolkit

8.1 MERCURY IN MEDICAL DEVICES

Mercury-containing devices have long been used in hospitals and health care settings. These include fever thermometers, blood pressure measuring devices (sphygmomanometers), and esophageal dilators.

When such devices break, the mercury they contain can vaporize and expose health care workers and patients. Mercury from breakages can contaminate the immediate area of the spill as well as the facility's wastewater discharges. Such equipment breakages are common. Hospitals using mercury fever thermometers frequently report that they replace multiple thermometers per year for each hospital bed. One survey reported that in a 250-bed hospital, 4,700 mercury-containing fever thermometers were broken in a single year.[115]

Each mercury fever thermometer contains between 0.5 g and 3 g of mercury[116] while a mercury blood pressure device generally contains between 100 g and 200 g of mercury.[117] An esophageal dilator is a long, flexible tube that is slipped down a patient's throat into the esophagus for certain medical procedures. Although they are not as common as fever thermometers and blood pressure measuring devices, each dilator can contain as much as a kilogram of mercury.[118]

Good and affordable alternatives to mercury-containing fever thermometers, blood pressure measuring devices, and esophageal dilators are now widely available in many countries, and efforts are underway to phase out mercury-containing health care devices.[119] The international NGO network Health Care Without Harm (HCWH) plays a leading role in many of these efforts.[120] Together with the WHO, HCWH is leading a global initiative to achieve the virtual elimination of mercury-based thermometers and sphygmomanometers and to substitute accurate, economically viable alternatives for them by 2020. This initiative maintains a joint WHO/HCWH website and is recognized as a component of UNEP's Global Mercury Partnership program.

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115 "Market Analysis of Some Mercury-Containing Products and Their Mercury-Free Alternatives in Selected Regions," Gesellschaft für Anlagenund Reaktorsicherheit (GRS) mbH, 2010, http://www.ipen.org/ipenweb/documents/ipen%20documents/grs253.pdf.

116 "Thermometers and Thermostats," Environment Canada, http://www.ec.gc.ca/mercure-mercury/default.asp?lang=En&n=AFE7D1A3-1#Fever.

117 Sphygmomanometers, Local Governments for Health and the Environment, http://www.lhwmp.org/home/mercury/medical/sphygmom.aspx.

118 "Mercury Legacy Products: Hospital Equipment," Northeast Waste Management Officials' Association, http://www.newmoa.org/prevention/mercury/projects/legacy/healthcare.cfm#es.

119 See "The Global Movement for Mercury-Free Health Care," Healthcare Without Harm, 2007, http://noharm.org/lib/downloads/mercury/Global_Mvmt_Mercury-Free.pdf.

120 The Health Care Without Harm website is http://www.noharm.org/.

In 2007, the European Parliament approved legislation that will prohibit the sale within the E.U. of new mercury fever thermometers and will also restrict sales of other mercury-containing measuring devices.[121] Several European countries including Sweden, the Netherlands, and Denmark have already banned the use of mercury thermometers, blood pressure devices, and a variety of other equipment. In the United States, thirteen state governments have legislated bans on mercury thermometers, and thousands of hospitals, pharmacies, and medical-device purchasers have voluntarily switched from mercury-containing devices to digital thermometers and to aneroid and digital blood pressure devices.[122] In the Philippines, the Department of Health issued a 2008 administrative order calling for the gradual phase-out of mercury thermometers in all health facilities nationwide.[123] In Argentina, the Minister of Health signed a resolution in 2009 that instructs all hospitals and health care centers in the country to purchase mercury-free thermometers and blood pressure devices.[124] In 2011 the Mongolian government announced a ban on further procurement of mercury containing thermometers and sphygmomanometers and dental amalgams in the health care sector. In January 2013 Mongolia announced that 14 of its tertiary and secondary hospitals were now certified mercury-free.[125]

On February 13, 2013 the Sri Lankan government announced it would remove all mercury containing medical equipment from use in hospitals to reduce mercury exposure. All mercury-based equipment will be replaced with electronic alternatives.[126]

In most developing countries and countries with economies in transition, however, the move away from mercury-containing medical devices generally has been slower. In some places, there is limited awareness of the need to make this change.

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121 "EU Ban on Mercury Measuring Instruments," U.K. Office of the European Parliament, 2007, http://www.europarl.org.uk/section/2007-archive/eu-ban-mercury-measuring-instruments.

122 "The Global Movement for Mercury-Free Health Care," Healthcare Without Harm, cited above.

123 Environmental Health News, June 21, 2010, http://www.noharm.org/seasia/news/.

124 "Argentina Ministry of Health Issues Resolution Ending Purchase of Mercury Thermometers and Sphygmomanometers in the Country's Hospitals," February 24, 2009, http://www.noharm.org/global/news_hcwh/2009/feb/hcwh2009-02-24b.php.

125 Tsetsegsaikhan B (2013) *Media Release*: "MERCURY FREE HOSPITALS" ARE ANNOUNCED IN MONGOLIA Mongolian Ministry of Health. Olympic street, Government building VIII, Ulaanbaatar, Mongolia

126 ColomboPage News Desk, (2013) Sri Lanka Health Ministry to remove mercury-containing medical equipment from hospitals. Colombopage, Sri Lanka Internet Newspaper. February 13, 2013. accessed online at: http://www.colombopage.com/archive_13A/Feb13_1360739756CH.php

However, even as awareness of the need to phase out mercury-containing devices in health care grows, three important barriers to change remain:

- Distrust of the available mercury-free alternatives by some health professionals.
- An inadequate market supply of accurate and affordable mercury-free devices.
- A lack of national, regional, or global standard-setting and device-certification programs to ensure that devices available on the national market meet accepted accuracy and performance criteria.

As a long-term strategy, the WHO supports a move toward bans on the use of mercury-containing medical measuring devices and replacing them with effective mercury-free alternatives in all countries. In the short term, the WHO encourages countries that have access to affordable alternatives to develop and implement plans to reduce the use of mercury equipment and replace it with alternatives. In the interim, the WHO also encourages hospitals to develop mercury cleanup, waste-handling and storage procedures.[127]

What does the mercury treaty say about mercury in medical devices?

The mercury treaty requires a phase-out of the manufacture, import and export of all mercury containing medical measuring devices (fever thermometers and sphygmomanometers) by 2020. (This provision does not apply to dental amalgams which are addressed separately.) Countries can opt for exemptions that push that phase-out date back to 2030.

8.2 MERCURY-CONTAINING SWITCHES

Several kinds of electrical switches contain mercury. These include tilt switches, float switches, thermostats, relays that control electronic circuits, and others.[128] In 2004, for example, new switches, thermostats, and relays sold in the United States contained approximately 46.5 metric tons of elemental mercury.[129] Good alternatives are available for virtually all of these.

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127 "Mercury in Health Care," WHO Division of Water Sanitation and Health, http://www.who.int/water_sanitation_health/medicalwaste/mercury/en.

128 "What Devices Contain Mercury?" U.S. EPA Software for Environmental Awareness, Purdue University, http://www.purdue.edu/envirosoft/mercbuild/src/devicepage.htm.

129 "Mercury Use in Switches and Relays," Northeast Waste Management Officials' Association (NEWMOA), 2008, http://www.newmoa.org/prevention/mercury/imerc/factsheets/switches.cfm. (Note: Weights reported in pounds in the original were converted to metric tons.)

Two European Union directives that entered into force in 2005 and 2006 ban the sale in European countries of switches and thermostats that contain mercury: WEEE (Waste Electrical and Electronic Equipment) and RoHS (Restrictions in the Use of Hazardous Substances).[130] Several U.S. state governments also enacted bans on mercury-containing switches and thermostats. In response to these measures, many manufacturers have replaced these switches with mercury-free alternatives. As a result, the number of mercury-containing switches sold in North America and Western Europe has been rapidly declining. Less information is available on trends in the use of mercury-containing switches in developing countries and countries with economies in transition.

Tilt switches: These are switches that contain small tubes with electrical contacts at one end. When the end of the tube with the electrical contacts is tilted down, mercury flows to that end and closes the circuit. When that end of the tube is tilted up, the circuit is broken.[131]

Tilt switches have been commonly used in automobiles to control lamps in trunks and at other locations. Each switch contains, on average, 1.2 g of elemental mercury. It was estimated that in 2001, automobiles on the road in the United States contained 250 million mercury tilt switches.[132] In recent years, almost all automakers have discontinued placing tilt switches in new vehicles. Sweden banned tilt switches in automobiles in the early 1990s. European auto manufacturers responded by discontinuing virtually all use of mercury tilt switches in 1993. American automakers followed in 2002.[133] And it appears that virtually all automakers in the world have now discontinued their use. Many older vehicles, however, still contain mercury switches that, unless removed and properly disposed of, will release their mercury into the environment when the vehicles are scrapped.

Tilt switches have also been used in many other products, although their use has become less prevalent in recent years. These products include washing machines, clothes dryers, freezers, clothes irons, space heaters, television sets, furnace fan limit control switches, security and fire alarm systems, children's novelty shoes with blinking lights, and many others.[134] Tilt switches are also used in industrial

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130 "Understanding RoHS," the ABB Group, 2006, http://library.abb.com/GLOBAL/SCOT/scot209.nsf/VerityDisplay/32F49F4B89A16FF4852573A300799DB4/$File/1SXU000048G0201.pdf.

131 Ibid.

132 "Reducing and Recycling Mercury Switch, Thermostats and Vehicle Components," Illinois Environmental Protection Agency, 2005, http://www.epa.state.il.us/mercury/iepa-mercury-report.pdf.

133 Ibid.

134 "Table of Products That May Contain Mercury and Recommended Management Options," U.S. EPA, http://www.epa.gov/wastes/hazard/tsd/mercury/con-prod.htm.

applications where a single switch might contain as much as 3.6 kg of elemental mercury.[135] Very sensitive mercury switches are sometimes used in gyroscopes and artificial horizons, especially in aerospace and military applications.[136]

Float Switches: These are commonly used to operate pumps and control the level of a liquid. A float switch is a round or cylindrical float with a switch attached to it. The switch operates a pump and turns the pump on or off when the float rises above or sinks below a certain height.[137] An individual float switch may contain as little as 100 mg of mercury or as much as 67 g. Small float switches are used in sump pumps that prevent basement flooding. Larger ones are used in municipal sewer systems, as controls for irrigation pumps and for many industrial applications. Alternatives for mercury-containing float switches are readily available at similar prices.[138]

Thermostats: These are used in homes and elsewhere to control heating and cooling devices. Until recently, most thermostats contained mercury. Mercury thermostats have bimetal coils that contract and expand with room temperature. When the coil contracts or expands, it activates a mercury switch that opens or closes a circuit to make a furnace, heat pump, or air conditioner turn on or off. The average total amount of mercury in a residential analog thermostat is approximately 4 g. Industrial thermostats may contain much more mercury.[139]

In recent years, many manufacturers have replaced mercury-containing thermostats with mercury-free electromechanical or digital thermostats. In the U.S., for example, the mercury content of new thermostats sold in 2004 (13.1 metric tons) was not much different from the mercury content of new thermostats sold in 2001 (13.25 metric tons). By 2007, however, there had been a nearly 75 percent reduction in the mercury content of new thermostats sold (down to 3.5 metric tons).[140] Mercury-containing thermostats have largely been replaced with electronic thermostats that are programmable and that pay for themselves very quickly in the energy savings they provide the customer. Care must be taken to ensure that when electronic thermostats are installed as a replacement for mercury thermostats, the older thermostats are properly managed.

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135 "Mercury Use in Switches and Relays," NEWMOA cited above.

136 "Mercury Gyro Sensors," Polaron Components, http://www.coopercontrol.com/components/mercury-gyro.htm.

137 "What Devices Contain Mercury," cited above.

138 "Mercury Use in Switches and Relays," NEWMOA cited above.

139 "Fact Sheet: Mercury Use in Thermostats," Interstate Mercury Education and Reduction Clearinghouse (IMERC), 2010, http://www.newmoa.org/prevention/mercury/imerc/factsheets/thermostats.pdf.

140 Ibid.

Mercury-Containing Relays: These are devices that open or close electrical contacts to control the operation of other devices. Relays are often used to turn on and off large current loads by supplying relatively small currents to a control circuit. Mercury-containing relays include mercury displacement relays, mercury wetted reed relays, and mercury contact relays.[141]

Relays are widely used in many different products and applications. The global market for relays in 2001 was U.S.D 4.658 billion in revenues. The largest users of relays are the telecommunications, transportation, and industrial automation industries. Relays can be found in notebook computers and computer power supplies, copiers, battery chargers, heaters and ovens, industrial furnaces, street lamps and traffic signals, surgical equipment and X-ray machines, aircraft, voltmeters and ohmmeters, machine tool controls, mining equipment, pool heaters, dry-cleaning equipment, circuit boards, programmable logic controllers, and many other applications.[142] In the United States in 2004, new relays entering the market contained 16.9 metric tons of mercury.[143]

There are many types of mercury-containing switches and relays besides those described above. These include pressure and temperature switches, flame-sensor switches, reed switches, vibration switches, and others. Most of the easily available information about mercury-containing switches comes from North America and Western Europe, where such switches are largely being replaced by mercury-free alternatives. There is not good information about whether similar trends have begun in other regions.

Much of the mercury that is contained in switches in existing products and equipment will eventually enter the environment unless measures are taken to recover this mercury. Unfortunately, the present trend is for highly industrial countries to ship their electronic wastes to low-wage areas in the developing world, where most waste-processing facilities are poorly run and managed and often create local pollution problems.

What does the mercury treaty say about mercury in switches?

The mercury treaty will help drive the phase-out of these products as it requires most mercury-based switches (there are some military and civil defense exemptions) to be phased out by 2020. Exemptions are available to Parties to the treaty that can extend the phase out date to 2030.

141 "Mercury Use in Switches and Relays," NEWMOA cited above.

142 "An Investigation of Alternatives to Mercury Containing Products," Lowell Center for Sustainable Production, 2003, http://sustainableproduction.org/downloads/An%20Investigation%20Hg.pdf.

143 "Mercury Use in Switches and Relays," NEWMOA cited above.

8.3 MERCURY IN BATTERIES

The main use of mercury in batteries is to prevent a buildup of hydrogen gas that can cause the battery to bulge and leak. Mercury has also been used as an electrode in mercuric oxide batteries. In the United States, as recently as the early 1980s, battery manufacturing was the largest single domestic use of mercury; it consumed more than 900 metric tons of mercury per year. By 1993, many battery manufacturers were selling mercury-free alkaline batteries for most applications, and by 1996, this became the national standard for most battery applications following the adoption of a federal law regulating mercury-containing batteries. Western European countries put similar restrictions in place. Globally, however, mercury continued to be widely used in battery production; batteries reportedly accounted for about one-third of total global mercury demand in the year 2000.[144]

According to a European Union report, the total mercury content in batteries sold in both the U.S. and in E.U. countries in 2000 was 31 metric tons. In the same year, the mercury content of batteries sold in the rest of the world was 1,050 metric tons.[145] A more recent estimate in the UNEP report "Summary of Supply, Trade and Demand Information on Mercury" suggests that global mercury content of new batteries sold in 2005 had declined to somewhere between 300 and 600 metric tons.[146] The most recent UNEP assessment[147] suggests that global mercury use in batteries continues to decline with between 230-350 tons of mercury used in battery manufacture.

The batteries that have the highest mercury content are mercuric oxide batteries, which are 40 percent mercury by weight. These batteries have been valued for having a high-energy density and a flat voltage curve and have been used in applications such as hearing aids, watches, calculators, electronic cameras, precision instruments, and medical devices.[148] We have not, however, been able to find any evidence that small mercuric oxide batteries are still being produced anywhere in the world. On the other hand, large mercuric oxide batteries are still produced for use in military and medical applications and in industrial equipment where a stable current and a long service life are considered to be essential. According to a

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144 "Mercury: Consumer and Commercial Products," U.S. EPA, http://www.epa.gov/hg/consumer.htm#bat.

145 "Mercury Flows in Europe and the World," cited above.

146 "Summary of Supply, Trade and Demand," UNEP, cited above.

147 AMAP/UNEP, 2013. Technical Background Report for the Global Mercury Assessment 2013. Arctic Monitoring and Assessment Programme, Oslo, Norway/UNEP Chemicals Branch, Geneva, Switzerland. vi + 263 pp. Table A.3.1 page 103

148 "Fact Sheet: Mercury Use in Batteries," (IMERC), 2008, http://www.newmoa.org/prevention/mercury/imerc/factsheets/batteries.pdf.

European Commission report, in the year 2007, mercuric oxide batteries containing between 2 and 17 metric tons of mercury were sold in E.U. countries.[149]

Mercury-containing batteries other than mercuric-oxide batteries use mercury to inhibit gas formation inside the battery and to prevent leakage. Most alkaline batteries on the world market no longer contain mercury. The main exception is alkaline button cell batteries.

Button cell batteries are small batteries used in hearing aids, watches, toys, novelties, and other small, portable devices. Many of these batteries contain mercury. The four major button battery technologies are zinc air, silver oxide, alkaline manganese, and lithium. Lithium button batteries do not contain mercury. On the other hand, zinc air, silver oxide, and alkaline manganese button batteries typically contain from 0.1 percent to 2.0 percent mercury by weight. Many of these batteries enter commerce through the sale of products with the battery already embedded. As an example, in 2004, 17 million Spider Man toys were distributed in breakfast cereals sold in the U.S. It is estimated that this single promotional campaign brought 30 kilograms of mercury into circulation.[150]

Zinc Air Button Batteries: The majority of these are sold for use in hearing aids, a demanding use that requires a high-energy battery. These batteries generally have a useful life of only a few days, and hearing aid users buy multiple replacement batteries at a time. Reliable, mercury-free zinc air button batteries are on the market in some countries at prices equivalent to their mercury-containing counterparts.[151]

Silver Oxide Button Cell Batteries: These batteries are used mainly in watches and cameras, but also may be used in miniature clocks, electronic games, calculators, and other products that require a flat discharge profile. Three Japan-based companies—Sony, Seiko, and Hitachi—have offered mercury-free silver oxide button batteries in a variety of sizes for several years. Recently, companies in Germany and China have also begun to produce them. Mercury-free silver oxide button batteries from some producers are the same price as their mercury-containing counterparts, while batteries from some other producers are slightly more costly

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149 "Options for Reducing Mercury Use in Products and Applications, and the Fate of Mercury Already Circulating in Society; COWI A/S and Concorde East/West Sprl European for the European Commission Directorate-

General Environment, 2008, http://ec.europa.eu/environment/chemicals/mercury/pdf/study_summary2008.pdf.

150 "Mercury-Free Button Batteries: Their Reliability and Availability," Maine Department of Environmental Protection, 2009, www.maine.gov/dep/rwm/publications/legislativereports/buttonbatteriesreportjan09.doc.

151 Ibid.

to purchase. It appears that mercury-free silver oxide button batteries are rapidly gaining market share.[152]

Alkaline Manganese Button Cell Batteries: This is the battery type of choice for toys and novelties that contain button cells and is also used in many other products such as cameras, calculators, digital thermometers, and remote controls. It has been estimated that China used more than 900 metric tons of mercury in 2004 in the manufacture of alkaline manganese button cells. These are the least costly of the button cell battery types, and popular sizes are available in bulk quantities at prices of U.S.D 0.10 per battery or less.

There are at least five Chinese manufacturers who offer mercury-free alkaline manganese button cell batteries in a variety of sizes. These include New Leader, Super Energy, Chung Pak, Pak Ko, and Shenzhen Thumbcells. These companies sell the batteries mainly to original equipment manufacturers for use in end products. According to one researcher, ingredients such as bismuth, indium, and organic surfactants can be used to replace the mercury in alkaline manganese button cell batteries with little or no technical difficulty.[153]

Lithium Miniature Batteries: These batteries are shaped more like a coin than a button and have no added mercury. Timex uses lithium batteries in 95 percent of its watches, and lithium batteries also are common in electronic games, calculators, car-lock systems, garage door openers and greeting cards. Some have suggested lithium batteries could make a good alternative to mercury containing button cells in many applications. However, doing so would require that products be redesigned to accommodate a different physical battery shape because lithium batteries are typically flatter and wider than button cells. Lithium batteries also have a much higher operating voltage than button cells, which may make them unsuitable for many current applications.[154]

Mercury is released into the environment from batteries during manufacture and at the end of the battery's useful life. Information on mercury emissions and releases that result from the manufacture of mercury-containing batteries is not available, but the quantities could be substantial. However, the main way that mercury-containing batteries release mercury into the environment almost certainly occurs at the end of their useful life. In most countries, the recycling rate for batteries, especially button cell batteries, is very low, with most batteries ending up in incinerators, landfills, or waste dumps. These, in turn, sooner or later release much of the mercury content of the batteries to the environment.

152 Ibid.
153 Ibid.
154 Ibid.

What does the mercury treaty say about mercury in batteries?

There has been real progress in recent years toward replacing mercury-containing batteries with mercury-free alternatives, especially for batteries entering the Western European and North American markets.

This has been enhanced on a global basis by the mercury treaty that requires all batteries containing mercury (with the exception of button zinc silver oxide batteries with a mercury content < 2 percent and button zinc air batteries with a mercury content < 2 percent) must be phased out by 2020. Parties to the treaty can apply for exemptions that can extend this phase-out to 2030.

8.4 MERCURY IN FLUORESCENT LAMPS

Mercury is used in a variety of lamps and contributes to their efficient operation and life expectancy. Fluorescent and other mercury-containing lamps are generally much more energy efficient and longer lasting than incandescent and other equivalent forms of lighting.[155]

Fluorescent lamps, including both fluorescent tubes and CFLs, have, by far, the largest market share of all mercury-containing lamps. Fluorescent lamps generally contain less mercury than do other mercury-containing lamps, and the average mercury content of each individual fluorescent lamp has been decreasing. Nonetheless, because of their large market share, it has been estimated that fluorescent lamps represent approximately 80 percent of the total mercury used in lighting.[156]

A fluorescent lamp is a phosphor-coated glass tube that contains mercury and has electrodes located at both ends. When voltage is applied, the electrodes energize the mercury vapor in the tube, and this causes it to emit ultraviolet (UV) energy. The phosphor coating absorbs the UV energy and emits visible light. Mercury is an essential component of all fluorescent lamps.[157]

Nonetheless, under many circumstances, the use of compact fluorescent light lamps to replace incandescent bulbs will actually reduce total mercury releases into the environment. Why is this?

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155 "Fact Sheet: Mercury Use in Lighting," IMERC, 2008, http://www.newmoa.org/prevention/mercury/imerc/factsheets/lighting.cfm.

156 "The Truth About Mercury in Lamps and Bulbs," Progress Energy CurrentLines, http://www2.unca.edu/environment/documents/Mercury%20&%20Lighting.pdf.

157 "Fluorescent Lights and Mercury," North Carolina Division of Pollution Prevention and Environmental Assistance, http://www.p2pays.org/mercury/lights.asp.

Coal contains mercury that is released into the environment when the coal is burned. Most countries depend on coal-fired power plants for a high proportion of the electricity they use. As a result, measures that decrease electricity usage can decrease mercury emissions from coal-fired power plants.

IN SOME COUNTRIES, THE USE OF MERCURY-CONTAINING FLUORESCENT LIGHTING MAY, IN THE SHORT TERM, CONTRIBUTE TO REDUCING GLOBAL MERCURY POLLUTION

Fluorescent tubes and compact fluorescent lamps often contain a relatively small amount of mercury and are very energy efficient compared with incandescent bulbs. When large numbers of people use fluorescents in place of incandescent bulbs, this will, in general, greatly reduce total electricity demand. In most cases, this substitution can reduce mercury emissions from power plants by an amount that is greater than the amount of mercury contained in the fluorescent lamps themselves. This can be demonstrated with an example based on data from the United States. It should be noted, however, that for some developing countries and countries with economies in transition, some conclusions based on the conditions that prevail in highly industrial countries may not apply.

Consider a 14-watt CFL that is used to replace a 60-watt incandescent bulb. Both the 14-watt CFL and the 60-watt incandescent bulb produce approximately the same amount of light. In the United States, the average life of such a CFL is approximately 20,000 hours. Over this average life, the CFL will consume 280 kilowatt hours (kWh) of electricity. Over that same period, a 60-watt incandescent bulb will consume 1,200 kWh of electricity. By substituting a 14-watt CFL for a 60-watt incandescent bulb, under the conditions that prevail in the United States, one can save, on average, 920 kWh of electricity usage over the life of the CFL.

In the United States, an average coal-fired power plant emits approximately 0.0234 mg of mercury into the air for each kilowatt hour of electricity it generates. If we assume that a home in the U.S. gets all of its electricity from an average American coal-fired power plant, we find that replacing a 60-watt incandescent bulb with a 14-watt CFL reduces power plant mercury emissions by an average of 21.5 mg (and also reduces emissions of greenhouse gases, sulfur dioxide, nitrogen oxide, and other pollutants).

Because the average 14-watt CFL sold in the U.S. generally contains 5 mg of mercury or less, its use reduces total mercury emissions by approximately 16.5 mg of mercury, even if we assume that all the mercury in the CFL eventually enters the environment. (With 21.5 mg mercury conserved minus the 5 mg mercury contained in the CFL, you end up with a 16.5 mg reduction in mercury emissions.)[158],[159] Under these conditions, when fluorescents replace incandescent bulbs on a large scale, total reductions in mercury emissions can be significant.

On the other hand, conditions in some countries can be quite different. In Russia, for example, it appears that fluorescent lamps contain more mercury than is the case in the United States, with many lamps in Russia containing between 20 mg and 500 mg of mercury. Russian experts estimate that the total of all mercury currently contained in fluorescent lamps in use in Russia is approximately 50 metric tons. Given their burnout rate, it is estimated that these lamps are responsible for the release of approximately 10 metric tons of mercury into the environment each year.[160]

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158 "The Truth About Mercury in Lamps and Bulbs," Progress Energy Current Lines, cited above.

159 "Compact Fluorescent Bulbs and Mercury: Reality Check," *Popular Mechanics*, May 2007, http://www.popularmechanics.com/home/reviews/news/4217864.

160 "Mercury Emission Sources in Russia; The Situation Survey in Six Cities of the Country," Eco-Accord Centre, June 2010 http://www.zeromercury.org/projects/Russian%20Mercury%20sources%20Eng-Final.pdf.

In Russia and in many other countries, voltage regulation of the power supply is inconsistent, and electricity consumers experience numerous sharp power spikes. As a result, the life expectancy of fluorescent lamps in Russia tends to be shorter than in countries that have a more stable electrical power supply.[161]

These and other considerations influence both the benefits and the costs associated with a conversion from incandescent bulbs to fluorescent lamps. For example, the mercury content of coal varies from country to country and region to region as does the amount of mercury released per kilowatt hour of production from the average coal-fired power plant. Also, the proportion of the electrical supply derived from coal-fired power plants varies from place to place. Some countries have relatively good systems for ensuring that fluorescent lamps are collected at the end of their useful life and managed in ways that minimize mercury releases into the environment while some other countries have no such systems in place. There are also differences between countries in the relative cost of fluorescent lamps. Finally, it is possible that in countries where electricity prices are relatively low, where the cost of fluorescent lamps is very high, and where fluorescent lamps tend to have a shortened life span, conversion from incandescent to fluorescents may result in a net cost to consumers rather than a net savings.

In the end, experts in different countries and regions may reach different conclusions about the desirability of phasing out incandescent bulbs for fluorescent lamps in their countries. A number of factors may go into such decision making. On the one hand, experts will consider climate change and the importance of measures to reduce electricity demand on power plants fired by coal or other fossil fuels, and they will consider power plant emissions of mercury and other toxic pollutants. On the other hand, experts may also consider the mercury content of the fluorescents on their national markets and mercury emissions that occur at the point of lamp manufacture and at the point where the mercury was mined and refined. They may also give consideration to the more immediate health and safety concerns associated with bringing mercury-containing products into homes and workplaces and the likelihood that people will just dump burned-out lamps. Other considerations may include the average operating life of fluorescent lamps in the country and the relative cost to consumers of incandescent bulbs versus fluorescents.

Finally, those who support the phase-out of incandescent bulbs and replacing them with fluorescent lamps recognize that this is not a satisfactory permanent solution but only a short-term or midterm measure. The longer-term goal is the development and widespread use of lamps that provide good lighting and that are energy efficient, mercury free, long lasting, inexpensive, and nontoxic. There are clear indications that LED based lighting will fulfil this role in the near future as costs drop rapidly. They may also provide an opportunity for many countries to 'leap frog' in technological terms from incandescent to LED lighting without adopting mercury based CFLs. A key consideration will be how rapidly LED costs drop through economies of scale over the next few years.

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161 Private correspondence with a Russian NGO leader.

The use of fluorescents poses its own problems. Fluorescents release hazardous mercury vapors into the indoor environment when they break. Also, if we take into account all the mercury pollution associated with the life cycle of fluorescents, we need to consider not only the mercury content of the lamp and the pollution caused at the end of its useful life but also the mercury pollution associated with mining the mercury that goes into the lamp and the mercury pollution associated with producing the lamp.

Fortunately, new energy-efficient lamps that contain no mercury are being developed. The most promising is LED technology. LED lighting is becoming available at prices that can compete with CFLs. As more consumers invest in LED technology, costs can be expected to come down over time due to economies of scale. Retail prices for LED lamps have already fallen rapidly in the last few years as more consumers purchase them for domestic, commercial and automotive applications. Increasing electricity prices in many countries has also driven consumers to seek out the most energy efficient lighting available. Vendors claim that commercially available LED bulbs now coming onto the market contain no mercury, provide 77 percent energy savings over incandescent bulbs, last 25 times as long, are cool to the touch, and offer full brightness from the moment they are turned on (unlike fluorescents).[162]

Eventually, LED bulbs or other new technologies will almost certainly replace both incandescent bulbs and fluorescent lamps.

There is a growing amount of information available about the environmental and health impacts of LED bulbs, including a recent life-cycle assessment of LEDs by the U.S. Department of Energy. This study found that although LEDs used around three times the amount of energy during manufacture compared to CFL's with comparable light output, the minimal overall lifecycle energy use of LEDs far outweighed the manufacturing energy use (8.8 percent of total life-cycle energy use).[163]

In the short-term to mid-term, replacing incandescent bulbs with long-lived fluorescent lamps appears to be environmentally beneficial in many countries. Nonetheless, all fluorescent tubes and compact fluorescent lamps (CFLs) are not the same. In 2004, most fluorescent tubes sold in the U.S. contained less than 10 mg of mercury, but 12.5 percent of them contained more than 50 mg. Two-thirds

[162] "Light Bulb War? New LEDs by GE, Home Depot Compete," *USA Today*, May 10, 2010, http://content.usatoday.com/communities/greenhouse/post/2010/05/light-bulb-war-new-leds-by-ge-home-depot-compete/1.

[163] U.S. Department of Energy. (2012). Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products. Retrieved March 10, 2012 from http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_LED_Lifecycle_Report.pdf

of all CFLs sold in the U.S. in 2004 contained less than 5 mg but some contained more than 10 mg.[164] The average mercury content of size T12 fluorescent tubes manufactured in China in 2006 was between 25 mg and 45 mg, for size T5 tubes it was 20 mg, and for CFLs it was 10 mg.[165] In India, the most popular CFLs contain between 3.5 mg and 6 mg of mercury, but some contain much more.[166] For a number of years the Indian government has had draft legislation and standards requiring mercury content in CFLs to be limited to less than 5 mg per CFL. However ongoing resistance to the move by industry has resulted in 'limited trials' of the restricted mercury CFLs. The standard was developed by the Bureau of Indian Standards (BIS), but requires legislative support that has not yet been apparent to date. BIS officials[167] are also suggesting the government should do more to promote the use of mercury free LED lamps to overcome the environmental and health hazards associated with mercury based CFLs.

In Western Europe, the E.U. Parliament and Council have established a directive that restricts the use of mercury in electrical and electronic equipment. It requires the mercury content of CFLs to be below 5 mg per lamp and the mercury content of general-purpose fluorescent tubes to be below 10 mg per tube.[168] In some other countries, however, the average mercury content of fluorescents may be much higher.

In addition, knowing the mercury content of a fluorescent lamp does not tell the full story of its contribution to global mercury pollution. Some lamp manufacturers, such as many of those in China, source their mercury from small, highly polluting primary mercury mining and refining operations. Some factories that produce lamps have poor pollution controls and release large quantities of mercury vapors to the indoor or outdoor air. Some generate large quantities of poorly managed mercury-contaminated solid and liquid waste streams. On the other hand, some other lamp manufacturers create minimal amounts of pollution and source their mercury from well-controlled recycling operations that recover mercury that would otherwise enter the environment.

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164 "Fact Sheet: Mercury Use in Lighting," IMERC, cited above.

165 "Improve the Estimates of Anthropogenic Mercury Emissions in China," Tsinghua University, 2006, http://www.chem.unep.ch/mercury/China%20emission%20inventory%20.pdf.

166 "Information on CFL and Its Safe Disposal," Electric Lamp and Component Manufacturers Association of India, http://www.elcomaindia.com/CFL-Safe-Disposal.pdf.

167 Business Standard (2011) Standard for mercury level checking in CFL lamp formulated: BIS. accessed online at http://www.business-standard.com/article/economy-policy/standard-for-mercury-level-checking-in-cfl-lamp-formulated-bis-111100300055_1.html

168 "Directive 2002/95/EC of the European Parliament and of the Council," *Official Journal of the European Union*, http://www.dtsc.ca.gov/HazardousWaste/upload/2002_95_EC.pdf.

The lack of a functional system to ensure the environmentally sound management of spent mercury-containing lamps, especially in developing countries, poses serious threats to waste workers and their communities, who often retrieve waste lamps from mixed trash disposed in dump sites or landfills and recycle them in uncontrolled conditions. In the Philippines, for example, government data indicates that 88 percent of households and 77 percent of commercial establishments disposed of their waste fluorescents as domestic waste. The investigative work of the EcoWaste Coalition, a member of IPEN, on the informal recycling of CFLs in dump sites has caught the attention of policy makers who now see the need to put in place an effective mechanism for the collection and recovery of end-of-life lamps, including the imposition of extended producer responsibility (EPR) to curb inappropriate disposal.

This problem is not unique to countries with developing economies. The Association of Lamp and Mercury Recyclers (ALMR) in the United States estimates that only about 23 percent of all lamps get recycled (30 percent of commercial and industrial but only 5 percent of residential).[169] Recycling rates in the E.U. are much higher. The European Community's Waste Electrical and Electronic Equipment directive provides for free take-back of end-of-life electrical equipment including fluorescents and for the establishment of collection facilities and collection systems for electronic wastes from private households.[170] Canada is also beginning to implement its own Canada-Wide Standard requiring the development of an Extended Producer Responsibility scheme for a growing list of consumer goods.[171]

Many different kinds of systems are used to manage and process end-of-life fluorescent lamps. These include lamp crushers and other kinds of fluorescent lamp recycling systems. No comprehensive data appears to be available on several factors related to these systems: the amount of atmospheric emissions released from different kinds of lamp crushing or recycling systems, the workplace occupational mercury exposures, the mercury ground and water pollution at the plant site, off-site mercury waste transfers, and how much pure elemental mercury different systems are able to recover. It appears, however, that while some may be relatively good, some other lamp crushing and recycling systems may be highly polluting and may cause significant occupational and/or community mercury exposures.

169 "Promoting Mercury-Containing Lamp Recycling: A Guide for Waste Managers," Solid Waste Association of North America, p. 1, http://www.swana.org/extra/lamp/lropmanualfinal.pdf.

170 "Waste from Electrical and Electronic Equipment," Citizens Information website, http://www.citizensinformation.ie/categories/environment/waste-management-and-recycling/waste_from_electric_and_electronic_equipment.

171 "Canada Wide Action Plan for Extended Producer Responsibility," Canadian Council of Ministers of the Environment, 2009, http://www.ccme.ca/assets/pdf/epr_cap.pdf.

The mercury treaty includes measures that will limit the mercury content of compact fluorescent lamps to 5 mg or less for the equivalent of a 30 watt bulb with CFL's containing higher levels of mercury to be phased out by 2020 (although renewable 5-year exemptions can be repeated twice making the effective phase-out date 2030). Linear fluorescent bulbs - triband lamps less than 60 watts and containing greater than 5 mg mercury and halophosphate lamps less than 40 watts and containing greater than 10 mg mercury are also subject to the same phase-out period.

8.5 OTHER MERCURY-CONTAINING LAMPS

In addition to fluorescent lamps, a number of other kinds of lamps on the market also contain mercury. Many of them are considered high-intensity discharge lamps (HID). This name is commonly used for several types of lamps, including metal halide, high-pressure sodium, and mercury vapor lamps.

HID lamps operate similarly to fluorescent lamps. They use a gas-filled tube that contains a metallic vapor at a relatively high pressure. They have two electrodes, and when an arc is established between them, it produces extremely high temperatures and visible radiant energy. These lamps have very long lives, and some of them put out much more light than typical fluorescent lamps. They require a relatively long warm-up period to achieve full light output and even a momentary loss of power causes the warm-up to start again—a process that can take several minutes. Different kinds of high-intensity lamps use different gas combinations in the arc stream—generally it's xenon or argon and mercury—and this affects the lamp's color characteristics and overall efficiency.[172]

Metal halide lamps: These lamps use metal halides such as sodium iodide in their arc tubes and produce light in most regions of the spectrum. Metal halide lamps provide high efficiency, good color rendition, and long service life and are commonly used in stadiums, warehouses, department and grocery stores and industrial settings. They are also used for bright blue-tinted car headlights and for aquarium lighting. The amount of mercury used in individual metal halide lamps ranges from more than 10 mg to 1,000 mg. Seventy-five percent of metal halide lamps contain more than 50 mg of mercury; one-third of them contain more than 100 mg of mercury.[173]

Ceramic metal halide lamps: These were recently introduced to provide a high-quality, energy-efficient alternative to incandescent bulbs and halogen lamps. They are mainly used for accent lighting and retail lighting. They differ from standard

[172] "Fact Sheet: Mercury Use in Lighting," IMERC, cited above.
[173] Ibid.

metal halide lamps in that the arc tube is made of ceramic. These lamps contain less mercury than standard metal halide lamps and also provide better light quality and better color consistency at a lower cost. More than 80 percent of these lamps contain less than 10 mg of mercury and the rest contain less than 50 mg of mercury.[174]

High-pressure sodium lamps: These lamps are a highly efficient light source, but tend to look yellow and provide poor color rendition. They were developed as energy-efficient sources for exterior, security, and industrial lighting applications and are widely used in street lighting. High-pressure sodium lamps give off a yellow to orange color light and, because of their poor color-rendering, are used mainly for outdoor and industrial applications where high efficiency and long life are priorities. Virtually all high-pressure sodium lamps contain between 10 mg and 50 mg of mercury.[175]

Mercury vapor lighting: This is the oldest technology of the high-intensity discharge lamps. The arc produces a bluish light that renders colors poorly, so most mercury vapor lamps have a phosphor coating to alter the color and somewhat improve color rendering. Mercury vapor lamps have a lower light output and are the least efficient of the high-intensity discharge lamps. They are mainly used in industrial applications and for outdoor lighting because of their low cost and long life. Most contain between 10 mg and 50 mg of mercury, but 40 percent contain more than 50 mg of mercury and 12 percent contain more than 100 mg of mercury.[176]

Cold cathode fluorescent lamps (CCFLs): These are a variation on fluorescent tubes but have a small diameter. CCFLs are used for backlighting in liquid crystal displays (LCDs) for a wide range of electronic equipment, including computers, flat-screen TVs, cameras, camcorders, cash registers, digital projectors, copiers and fax machines. They are also used for backlighting instrument panels and entertainment systems in automobiles. CCFLs operate at a much higher voltage than conventional fluorescent lamps. This eliminates the need for heating the electrodes and increases the efficiency of the lamp 10 to 30 percent. They can be made of different colors, have high brightness, and long life. Their mercury content is similar to that of other fluorescent lamps.

Neon lights: These are gas-discharge bulbs that commonly contain neon, krypton, and argon gasses at low pressure. Like fluorescent bulbs, each end of a neon light contains a metal electrode. Electrical current passing through the electrodes ion-

174 Ibid.
175 Ibid.
176 Ibid.

izes the neon and other gases, causing them to emit visible light. Neon emits red light; other gases emit other colors. For example, argon emits lavender and helium emits orange-white. The color depends on the mixture of gases and other characteristics of the bulb. Neon lights are usually made by artisans in small workshops and are widely used in advertising, commercial displays, and decoration. Red neon lights do not contain mercury, but other color neon lights can contain between approximately 250 mg and 600 mg of mercury per bulb.[177]

Mercury short-arc lamps: These are spherical or slightly oblong quartz bulbs with two electrodes that are only a few millimeters apart. The bulb is filled with argon and mercury vapor at low pressure. Wattage can range from less than 100 watts to a few kilowatts. The light created is extremely intense, and these lamps are used for special applications, such as search lights, specialized medical equipment, photochemistry, UV curing, and spectroscopy. A variation of this lamp is the mercury xenon short-arc lamp, which is similar but contains a mixture of xenon and mercury vapor. These lamps typically contain between 100 mg and 1,000 mg of mercury. Many contain more than 1,000 mg of mercury.[178]

Mercury capillary lamps: These provide an intense source of radiant energy from the ultraviolet through the near infrared range. They require no warming-up period for starting or restarting and reach near full brightness within seconds. Mercury capillary lamps come in a variety of arc lengths, radiant powers, and mounting methods. They are used in making printed circuit boards and other industrial applications. They are also used for UV curing—widely utilized in the silk-screen process, CD/DVD printing and replication, medical manufacturing, bottle/cup decorating, and coating applications. These lamps contain between 100 mg and 1,000 mg of mercury.[179]

What does the mercury treaty say about mercury in fluorescent lamps?

Article 4 of the mercury treaty lists high-pressure mercury vapor lamps, mercury in a variety of cold cathode fluorescent lamps and external electrode fluorescent lamps for phase-out by 2020 (with an option to extend this time limit to 2030).

8.6 MERCURY IN MEASURING DEVICES

Mercury expands and contracts evenly with changes in temperature and pressure. This characteristic has made mercury useful in scientific, medical and industrial devices that measure temperature and pressure.

177 Ibid.
178 Ibid.
179 Ibid.

The European Union has adopted a directive restricting some measuring devices that contain mercury. All mercury fever thermometers are banned from the market in E.U. countries. Other mercury-containing measuring devices intended for sale to the general public are also banned including manometers, barometers, sphygmomanometers (blood pressure measuring devices), and the other kinds of mercury thermometers. An exemption has been given to antique devices more than 50 years old, and the E.U. commissioned further study on the availability of reliable, safe, technically and economically feasible alternatives for mercury-containing devices for use in the health care field and in other professional and industrial applications.[180] A number of U.S. state governments have also adopted bans or restrictions on some mercury-containing measuring devices.[181] In response, a number of manufacturers have been moving away from these devices and have been increasing their production of high-quality, cost-effective, mercury-free alternatives.

Thermometers and sphygmomanometers are the most common mercury-containing measuring devices. Thermometers are used in a variety of applications such as fever thermometers as well as other types of thermometers used in homes and in industrial, laboratory and commercial applications. A thermometer may contain between 0.5 g and 54 g of mercury. In the U.S., for example, the mercury content of all thermometers sold in 2004 was approximately two metric tons. A sphygmomanometer contains between 50 g and 140 g of mercury. The mercury content of all sphygmomanometers sold in the U.S. in 2004 was approximately one metric ton.[182]

Because sphygmomanometers and some other mercury-containing measuring devices are open to the air, mercury is lost over time through volatilization. As a result, mercury must occasionally be replenished in these devices. Increasingly, the standard to which these instruments are recalibrated is from a non-mercury device, which indicates the accuracy and durability of non-mercury, electronic devices.

Other mercury-containing measuring devices include the following:

- **Barometers** measure atmospheric pressure. (Each may contain 400 g to 620 g of mercury.)

180 "Directive 2007/51/EC of the European Parliament and the Council of 25 September 2007 Relating to Restrictions on the Marketing of Certain Measuring Devices Containing Mercury," *Official Journal of the European Union*, March 10, 2007, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:257:0013:0015:EN:PDF.

181 "Fact Sheet: Mercury Use in Measuring Devices," IMERC, 2008, http://www.newmoa.org/prevention/mercury/imerc/factsheets/measuring_devices.pdf.

182 Ibid.

- **Manometers** measure differences in gas pressure. (Each may contain 30 g to 75 g of mercury.)
- **Psychrometers** measure humidity. (Each may contain 5 g to 6 g of mercury.)
- **Flow meters** measure the flow of gas, water, air, and steam.
- **Hydrometers** measure the specific gravity of liquids.
- **Pyrometers** measure the temperature of extremely hot materials. (They're primarily used in foundries.)

The mercury content of all manometers sold in the U.S. in 2004 was a little more than one metric ton. All the other measuring devices listed above that were sold in the U.S. in 2004, when taken together, contained 0.1 metric tons of mercury.[183]

What does the mercury treaty say about mercury in measuring devices?

Article 4 of the Mercury treaty lists non-electronic devices such as barometers, hygrometers, manometers, thermometers, and sphygmomanometers using mercury for phase-out by 2020 (with an option to extend the phase-out to 2030).

8.7 MERCURY IN DENTAL AMALGAM

Dental amalgam is a material used by dentists to fill dental caries, or cavities, caused by tooth decay. Dental amalgam fillings are also sometimes called silver fillings because they have a silver-like appearance. The amalgam is a mixture of metals that contains elemental mercury and a powdered alloy composed of silver, tin, and copper. By weight, approximately 50 percent of dental amalgam is elemental mercury. This technology is more than 150 years old.[184] In the past, dentists mixed amalgam on-site, using bulk elemental mercury and metal powders. Today, many dentists purchase dental amalgam in capsules that come in different sizes. The mercury content of each capsule can vary from 100 mg to 1,000 mg of mercury.[185]

A mercury amalgam dental filling releases mercury vapors in very small quantities, and these vapors can be absorbed into a person's bloodstream. It has been estimated that a person with amalgam dental fillings absorbs, on average, between 3 and 17 micrograms of mercury vapor into his or her blood each day. This is a

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183 Ibid.

184 "About Dental Amalgam Fillings," U.S. Food and Drug Administration, http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/DentalProducts/DentalAmalgam/ucm171094.htm#1.

185 "Fact Sheet Mercury Use in Dental Amalgam," IMERC, 2010, http://www.newmoa.org/prevention/mercury/imerc/factsheets/dental_amalgam.cfm.

small exposure, but it is much larger than the average human exposure that comes from the mercury content of the outdoor air we breathe.[186]

Studies of possible harms caused by mercury exposure from dental amalgam have come to widely differing conclusions. Some studies have found evidence suggesting that mercury from dental amalgam may lead to various health impairments including nephrotoxicity, neurobehavioral changes, autoimmunity, oxidative stress, autism, and skin and mucosa alterations. Evidence has also been cited that suggests a link between low-dose mercury exposure with the development of Alzheimer's disease and multiple sclerosis. The authors of a scientific review article that supports this view argue that some other studies of dental amalgam have substantial methodical flaws and that mercury levels in the blood, urine, or other biomarkers do not reflect the mercury load in critical organs. The authors state that there have been various trials in which the removal of dental amalgam has permanently improved chronic complaints in a relevant number of patients.

This review article concludes that "dental amalgam is an unsuitable material for medical, occupational, and ecological reasons."[187]

Other authoritative studies, however, have reached different conclusions. For example, the U.S. Food and Drug Administration (FDA) reviewed the available scientific evidence to determine whether the low levels of mercury vapor associated with dental amalgam fillings are a cause for concern. Based on this review, the FDA concluded that dental amalgam fillings are safe for adults and for children ages 6 and older.[188] Following this review, in 2009, the FDA updated its regulations governing dental amalgams. The new FDA regulations classify dental amalgams as posing a moderate risk. The FDA recommends warning patients who have mercury allergies about the use of dental amalgam. It also recommends that packaging materials for dental amalgam include statements to help dentists and patients make informed decisions. The statements should contain information about the scientific evidence on the benefits and risks of dental amalgam, including the risks of inhaled mercury vapor.[189]

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186 "Mercury," Chapter 6.9 in Air Quality Guidelines, WHO Regional Office for Europe, http://www.euro.who.int/document/aiq/6_9mercury.pdf.

187 J. Mutter et al., "Amalgam Risk Assessment with Coverage of References up to 2005," Institute for Environmental Medicine and Hospital Epidemiology, University Hospital Freiburg, http://www.iaomt.org/articles/files/files313/Mutter-%20amalgam%20risk%20assessment%202005.pdf.

188 "About Dental Amalgam Fillings," FDA, cited above.

189 "FDA Issues Final Regulation on Dental Amalgam," FDA, July 28, 2009, http://www.fda.gov/NewsEvents/Newsroom/Pressannouncements/ucm173992.htm.

In 2011, during negotiations for the mercury treaty, the U.S. government took the unprecedented step of announcing its support for an immediate "*phase down, with the goal of eventual phase out by all Parties, of mercury amalgam*." This goal was largely supported in the final text of the mercury treaty.

In response to both health and environmental concerns associated with dental amalgams, its use has been declining in the U.S. and Western Europe. (Trends in the rest of the world are not clear.) In 2007, the Norwegian Minister of the Environment issued a directive prohibiting the use of mercury in dental materials.[190] In 2009, Sweden followed suit, prohibiting the use of dental amalgam for children and restricting its use for adults to cases where there is a particular medical reason for its use and where other treatments have been judged insufficient.[191] Based on available evidence, Austria, Germany, Finland, Norway, the United Kingdom and Sweden have advised dentists to specifically avoid mercury-containing amalgam fillings during pregnancy.[192]

In the United States, the use of mercury dental amalgams has been declining. Between 2004 and 2007, the mercury content of dental amalgams used in the U.S. declined nearly 50 percent from 27.5 metric tons in 2004 to 15 metric tons in 2007.[193]

When dentists' use mercury amalgam fillings, mercury-containing wastes are generated that enter sewer systems and solid-waste streams. There is, however, a growing trend for many dentist offices to capture and recycle mercury wastes generated in their practices, and some national dental associations have established guidelines on best management practices for amalgam waste.[194]

In many countries, it is a common practice to cremate people after they die. In a crematorium, dental amalgam is vaporized and released into the air. There are no good statistics on how much mercury is released into the air globally from cremations. According to one 1995 estimate relating to cremations in the United States, approximately 500,000 people were cremated and this released approximately

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190 "Minister of the Environment and International Development Erik Solhei Bans Mercury in Products," press release, December 21, 2007, http://www.regjeringen.no/en/dep/md/press-centre/Press-releases/2007/Bans-mercury-in-products.html?id=495138.

191 "Dental Amalgam: Prohibition to Use Dental Amalgam," the Swedish Chemicals Agency (KemI), http://www.kemi.se/templates/Page_____3151.aspx.

192 Philippe Hujoel et al., "Mercury Exposure from Dental Filling Placement During Pregnancy and Low Birth Weight Risk," *American Journal of Epidemiology* (2005) 161 (8), p. 734-40, http://aje.oxfordjournals.org/content/161/8/734.full.

193 "Fact Sheet Mercury Use in Dental Amalgam," IMERC, cited above.

194 "Best Management Practices for Amalgam Waste," American Dental Association, 2007, http://www.ada.org/sections/publicResources/pdfs/topics_amalgamwaste.pdf.

1.25 metric tons of mercury into the air.[195] Cremation is very common in a number of countries, and this practice is growing rapidly in some others. In some cases, dental amalgams are removed prior to cremation to prevent mercury emissions. However, there has been cultural resistance to this practice. Emission controls on crematoria can also reduce mercury releases, but these can greatly increase costs.

There is a strong case for phasing out the use of dental amalgam and replacing it with safer alternatives. In doing so, we need adequate evaluations of proposed substitutes in order to ensure that we avoid alternatives with negative health or environmental impacts of their own.

What does the mercury treaty say about dental amalgam?

The mercury treaty both mandates that each nation phase down amalgam use, and prescribes what steps should be taken. Countries must conduct at least two of the phase down steps, which include:

- Promoting mercury-free alternatives.
- Changing dental school curriculum and re-training dentists.
- Encouraging insurance programs to favor mercury-free dental restorations over amalgam.
- Opt for a 'phase-down' of dental amalgam.

Actions available to NGOs to campaign for a rapid phase down of dental amalgam under article 4 of the mercury treaty are discussed in more detail at the top of section eight of this report.

8.8 MERCURY-CONTAINING PESTICIDES AND BIOCIDES

Both inorganic and organic mercury compounds have been used as pesticides for a number of applications. The compounds have been used in seed treatments, to control algae and slime in cooling towers and pulp and paper mills, as additives in marine paints and water-based paints and coatings, in tree-wound dressings, in protection for seed potatoes and apples, for fabric and laundry uses and others.[196]

In Australia, the pesticide Shirtan, which contains 120 g of mercury per liter in the form of methoxy ethyl mercury chloride, is still registered for use as a fungicide

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195 "Use and Release of Mercury in the United States," U.S. EPA, 2002, p. 64-5, http://www.epa.gov/nrmrl/pubs/600r02104/600r02104prel.pdf.

196 "Decision Guidance Documents: Mercury Compounds: Joint FAO/UNEP Programme for the Operation of Prior Informed Consent," 1996, www.pic.int/en/DGDs/MercuryEN.doc.

to control pineapple disease in sugarcane crops.[197] The Pesticide Action Network (PAN) lists 79 mercury-containing pesticides in its pesticides database.[198]

The Rotterdam Convention on Prior Informed Consent identifies the pesticide uses of elemental mercury and mercury compounds in its Annex III list of chemicals that cannot be exported to a country without the receiving country's prior informed consent. The convention identifies 44 mercury compounds whose use as a pesticide has been restricted by governments. The identified pesticide compounds include inorganic mercury compounds, alkyl mercury compounds, alkyloxyalkyl mercury compounds, and aryl mercury compounds. The Annex also lists mercury compound formulations in the form of liquids, wettable powders, granular materials, latex paints, formulation intermediates, and soluble concentrates.[199]

Many mercury-containing pesticides have been banned and restricted because of their toxicity to people, their ability to contaminate food and feed and their toxicity to aquatic organisms. The most serious cases of mercury pesticide toxicity have been associated with the use of mercury compounds as seed treatments that have been widely used to protect seeds against fungus infestations.

The first commercial mercury-based seed treatment formulation was a liquid called Panogen (methylmercury guanidine). It was developed in Sweden in 1938 and came into wide use by the late 1940s. Later, a dust formulation of ethylmethyl mercury called Ceresan was developed and widely used in treating small grains. Seed treatments using organomercury compounds were highly effective and were so inexpensive that many treating stations would apply them for no cost or little cost when a farmer brought in seed to be cleaned. Widespread use of mercury-containing fungicides continued until the 1970s, when restrictions began after several incidents of poisoning from people eating treated grain directly or eating meat from animals that had consumed treated grain. The use of organic mercury fungicides has been banned in many countries, but they may remain in use for certain applications in some others.[200]

A severe case of pesticide poisoning, sometimes called the Basra Poison Grain Disaster, occurred in 1971 in the Iraqi port of Basra. A shipment of 90,000 metric

197 "Shirtan Fungicide from Crop Care," http://www.fatcow.com.au/c/Crop-Care-Australasia/Shirtan-Fungicide-From-Crop-Care-p18475.

198 PAN Pesticides Database: Chemicals Name Search, http://www.pesticideinfo.org/Search_Chemicals.jsp.

199 "Annex III," Rotterdam Convention, http://www.pic.int/home.php?type=t&id=29&sid=30.

200 D. E. Mathre, R. H. Johnston, and W. E. Grey, "Small Grain Cereal Seed Treatment," 2006, Department of Plant Sciences and Plant Pathology, Montana State University, http://www.apsnet.org/edcenter/advanced/topics/Pages/CerealSeedTreatment.aspx.

tons of American barley and Mexican wheat intended for use as seed grain arrived in the port. The grain had been treated with methylmercury as an antifungal to prevent rot. It was supposed to go to farmers and had warnings printed on the bags in English and Spanish. However, these languages were not widely understood in the port city, and a large quantity was sold locally as food.[201] It is estimated that as a result of mercury poisoning, 10,000 people died and 100,000 were severely and permanently brain damaged.

Some other applications of mercury as a pesticide or biocide that may still be in use include the following:

- **Paint additives:** Phenyl mercuric compounds and mercuric acetate are sometimes added to paints as fungicides to prevent the growth of mold and mildew. These paints are no longer used in the United States and Western Europe, but may still be used in other regions.
- **Pulp and paper mills:** Phenyl mercury acetate is sometimes added to pulp in the paper-making process as a fungicide or slimicide. Because paper pulp is warm and rich in nutrients, fungi and slime molds can grow on the pulp and clog the machinery unless they are controlled. Large quantities of phenyl mercury acetate have been used for this purpose. This can contaminate both the pulp mill's discharge water and also the paper products themselves. Phenyl mercury acetate has also been added to pulp stored for shipping. There is little information available on whether this mercury application is still used.
- **Topical antibiotics:** Mercurochrome and Tincture of Merthiolate and some other topical antibiotics contain mercury and are used for both human and animal treatments for dressing wounds. These antibiotics are still in use, especially for veterinary applications.

What does the mercury treaty say about pesticides and biocides?

The mercury treaty lists biocides, pesticides and topic antiseptics containing mercury and its compounds for phase out by 2020. There are options to seek exemptions that would push this date back to 2030 but no further provisions for exemptions beyond that date are possible.

8.9 MERCURY IN LABORATORIES AND SCHOOLS

Elemental mercury as well as mercury compounds, mercury-containing reagents, and mercury-containing devices are frequently found in both school and professional laboratories.

[201] Wikipedia entry on the Basra poison grain disaster, http://en.wikipedia.org/wiki/Basra_poison_grain_disaster.

There have been numerous serious incidents of poisoning from mercury contamination in high schools. One prominent case occurred in 2006 at St. Andrew's School in Parañaque, Philippines. Students there found and began playing with 50 g of mercury intended for a science experiment. As a result, around 24 of the students, mostly aged 13, went to the hospital for close monitoring for mercury poisoning. The school remained closed for months while local and international experts cleaned up and decontaminated the building.[202] In February 2010, one of the students filed a civil case against his teacher and the school for the lifelong illness brought upon by mercury poisoning.[203]

Shortly thereafter, the Philippine Department of Education issued Memorandum No. 160, which reiterated the call of the Department of Health to phase out mercury and mercury-containing devices in health care facilities and institutions. It also called for a review of existing safety measures in science laboratories to ensure that mercury is excluded from the commonly used chemicals in school laboratory work. Ban Toxics, an NGO based in the Philippines and a member of IPEN, was instrumental in getting the Philippine Department of Education to issue this order.[204]

Another prominent incident occurred in 2009 at the Agua Fria High School in Arizona in the United States. Teachers there were using mercury for a lesson on density. Two students found a large bottle of mercury on a shelf near their desks, opened it, started playing with the mercury, and took some home. In the end, mercury contamination was found not only in the school but also on a school bus, in several homes, and on many students' personal items. Several hundred students and staff members were exposed, the cleanup cost the school district U.S.D 800,000, and the school superintendent resigned.[205]

The stories above are just two high-profile examples of a type of mercury exposure that is all too common. High schools have no need to do experiments and demonstrations that use mercury. This practice should be prohibited. If a school, laboratory, or other facility has a history of using mercury, accumulated mercury

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202 "There's Something About Mercury," Philippine Center for Investigative Journalism, December 31, 2007, http://pcij.org/stories/theres-something-about-mercury/.

203 Private correspondence with a Philippine NGO leader.

204 Ibid.

205 "How School's Huge Mercury Cleanup Unfolded," *The Arizona Republic*, November 29, 2009, http://www.azcentral.com/arizonarepublic/news/articles/2009/11/29/20091129 mercuryspill1129.html.

may still be present in floor drains or sink traps even after the practice has been discontinued, and this may be a cause for concern.[206]

Some laboratory uses of mercury may be appropriate when professional chemists or advanced students of chemistry in college laboratories perform them. However, we can and should eliminate or significantly reduce the use of mercury in labs because good alternatives can effectively replace most uses of elemental mercury, mercury compounds, and mercury-containing devices. For example, laboratories sometimes use a mercury-filled apparatus to maintain an inert atmosphere over a reaction and to provide pressure relief. Similar laboratory equipment filled with mineral oil is available, and labs should use these instead.[207] Labs can avoid most other mercury-containing equipment and devices as well. Some laboratories use zinc-mercury amalgam as a reducing agent but, again, good alternatives are usually available.[208] Mercury is also often present in lab chemicals and reagents, many of which have good substitutes.

Some hospital labs and other laboratories have decided to go virtually mercury free. Those who wish to do this should read container labels, material safety data sheets (MSDSs), and inserts that come with reagents. These will identify intentionally added mercury compounds in the reagents. However, MSDSs will generally not identify unintended mercury in the lab chemicals if the quantity is below 1 percent. This is because manufacturers are often not required to list the hazardous components of a product if they are present in concentrations below a certain level. Labs and hospitals, however, can ask sales representatives and product manufacturers about mercury in their products and can request a certificate of analysis or other data on the mercury content of laboratory products.[209]

8.10 MERCURY IN COSMETICS

Cosmetic products such as creams, lotions and soaps are sometimes marketed with the promise that their use will lighten the color of skin or remove dark spots. These products often contain mercury in the form of mercury chloride and/or ammoniated mercury. Both of these compounds are carcinogenic. Skin-lightening

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206 "How Do Schools Become Polluted by Mercury?" Minnesota Pollution Control Agency, http://www.pca.state.mn.us/index.php/topics/mercury/mercury-free-zone-program/mercury-free-zone-program.html?menuid=&missing=0&redirect=1.

207 "The Glassware Gallery: Bubblers, Lab and Safety Supplies," http://www.ilpi.com/inorganic/glassware/bubbler.html.

208 Wikipedia entry on reducing agents, http://en.wikipedia.org/wiki/Reducing_agent.

209 "Mercury in Health Care Lab Reagents," Minnesota Technical Assistance Program, http://www.mntap.umn.edu/health/92-mercury.htm.

cosmetics that do not contain mercury often contain hydroquinone ($C_6H_6O_2$), which is also highly toxic.[210]

In general, the more of the pigment melanin one has in his or her skin, the darker it is. Cosmetics that contain mercury compounds or hydroquinone initially cause the skin to lighten by inhibiting the production of melanin. In the longer term, however, these products make the skin blotchy, which in turn may cause the person to use more of it in an attempt to smooth out the color. Mercury-containing cosmetics have been banned in many countries, but they often remain available as under-the-counter items. They appear to be particularly popular in many Asian and African countries.[211]

One study suggests that many women in African countries use these products regularly, including 25 percent of women in Mali, 77 percent of women in Nigeria, 27 percent of women in Senegal, 35 percent of women in South Africa, and 59 percent of women in Togo. In a 2004 survey, 38 percent of women in Hong Kong, Korea, Malaysia, the Philippines, and Taiwan indicated that they use skin-lightening products. Many women use these products for long periods, sometimes for as long as 20 years.[212]

In 1999, the Kenya Bureau of Standards issued a public notice to inform and educate consumers about the harmful effects of mercury, hydroquinone, and the hormonal preparations and oxidizing agents that are contained in some cosmetic products on the market. In 2004, the Indonesian Food and Drug Control Agency (BPOM) issued a warning against 51 beauty-care products containing mercury. Many were imports, but in 2006, the police seized 200 boxes of cosmetic products containing mercury from a small manufacturing company in West Jakarta. In 2005, New York City's Department of Health and Mental Health issued a health alert recommending that New Yorkers immediately cease using all skin-lightening creams and soaps that list mercury as an ingredient as well as any cosmetic products that do not have a list of ingredients on the label.[213]

A study conducted by NGOs in the IPEN network found mercury in several skin-lightening products sold in Mexico. Of seven products analyzed, four contained detectable quantities of mercury, with one of them containing 1,325 parts per mil-

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210 Super Jolly, "Skin Lightening Products . . . ," Black History 365, http://www.black-history-month.co.uk/articles/skin_lightening_products.html.

211 Ibid.

212 "Mercury in Products and Wastes," UNEP Mercury Awareness Raising Package, http://www.chem.unep.ch/mercury/awareness_raising_package/C_01-24_BD.pdf (note: reference to the actual studies and surveys were not provided in the UNEP document).

213 Ibid.

lion (ppm). All the tested products came with a list of their ingredients, but none listed mercury as an ingredient.[214]

A Chicago newspaper tested skin-lightening creams sold in local stores and found that six of them contained mercury at levels that violated U.S. federal law. These six came from China, India, Lebanon, and Pakistan, and some were sold in stores specifically catering to these immigrant communities. Five of the creams contained more than 6,000 ppm mercury and one of them, manufactured in Pakistan, contained nearly 30,000 ppm mercury. This product was a white cream labeled as Stillman's Skin Bleach Cream. The store owner was reported as saying that he carried this cream because the product is so popular in Pakistan.[215]

So far in 2010, the Food and Drug Administration of the Philippines has banned 23 imported skin-lightening products that the agency described as "imminently injurious, unsafe, or dangerous" for containing impurities and contaminants beyond regulatory limits. For mercury, the allowable threshold is 1 ppm.

A 2000 European Union directive stipulates that mercury and its compounds may not be present as ingredients in cosmetics, including soaps, lotions, shampoos, and skin-bleaching products (except for phenyl mercuric salts for the conservation of eye makeup and products for removal of eye makeup in concentrations not exceeding 0.007 percent weight to weight).[216]

Although many jurisdictions have laws prohibiting the use of mercury-containing skin creams and soaps, most have had difficulties enforcing these laws.

Few jurisdictions prohibit the use of small amounts of mercury compounds in eye-makeup products such as mascara, and mercury is still widely found in these products. Mercury compounds are used in eye-makeup products as a germ killer and preservative, and they make the products last longer.[217] Though some manufacturers have removed mercury from some mascara products in response to consumer demand, most jurisdictions still allow the sale of makeup products that contain added mercury compounds. One exception is the U.S. state of Minnesota,

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[214] "Market Analysis of Some Mercury-Containing Products and Their Mercury-Free Alternatives in Selected Regions," conducted by IPEN, Arnika and GRS, 2010, http://www.ipen.org/ipenweb/documents/ipen%20documents/grs253.pdf.

[215] "Some Skin Whitening Creams Contain Toxic Mercury, Testing Finds," *Chicago Tribune*, May 19, 2010, http://www.chicagotribune.com/health/ct-met-mercury-skin-creams-20100518,0,7324086,full.story.

[216] "Mercury in Products and Wastes," UNEP Mercury Awareness Raising Package, cited above.

[217] "Mercury. . . In Your Mascara?" Planet Green, http://planetgreen.discovery.com/food-health/mercury-mascara.html.

where a law that took effect in 1998 totally banned all intentionally added mercury in cosmetics, including mascara and eye liners.[218]

What does the mercury treaty say about skin lighteners?

The mercury treaty requires the phase out of cosmetics including skin lightening products with mercury above 1 ppm by the year 2020. The exceptions to this phase out are mascara and other eye area cosmetics (because the treaty claims that no effective safe alternatives are available). As in the case of other products containing mercury listed under Article 4, there are options to extend the final date for phase out to 2030.

8.11 MERCURY IN MEDICINE

Doctors have often used mercury compounds as medicines.

Calomel

Physicians have used mercurous chloride (Hg2Cl2), or calomel, since at least the sixteenth century to treat malaria and yellow fever. A preparation called worm chocolate or worm candy was given to patients infested with parasitic worms.[219] Through the nineteenth and early twentieth century, many physicians continued to use calomel as a purgative, cathartic, and liver stimulant.[220] Parents frequently gave teething powders containing calomel to infants.[221]

Doctors continued to recommend the use of calomel into the 1950s in the United States, the United Kingdom, Australia and elsewhere for treating childhood teething and constipation. Mercury exposure from ingesting calomel often caused a common infantile and childhood illness called acrodynia, or pink disease. As late as 1950, acrodynia accounted for more than 3 percent of admissions to children's wards in London hospitals. Official statistics record that 585 children died of pink disease between 1939 and 1948 in England and Wales.[222] Calomel was not removed from the British Pharmacopoeia until 1958. The 1967 edition of the *United*

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218 "Mercury in Mascara? Minnesota Bans It," MSNBC, December 14, 2007, http://www.msnbc.msn.com/id/22258423/.

219 "Unregulated Potions Still Cause Mercury Poisoning," *Western Journal of Medicine*, July 2000, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1070962/.

220 *Columbia Encyclopedia* on mercurous chloride, http://www.answers.com/topic/calomel-1.

221 "The History of Calomel as Medicine in America," The Weston A. Price Foundation, 2009, http://www.westonaprice.org/environmental-toxins/1446.

222 "Unregulated Potions Still Cause Mercury Poisoning," *Western Journal of Medicine*, cited above.

States Dispensatory and Physicians' Pharmacology lists calomel as a medicine and not as a poison. After the childhood use of calomel was discontinued, pink disease virtually disappeared.[223]

WESTERN PHARMACEUTICAL USE OF CALOMEL

Physicians in the western medical tradition prescribed the use of calomel and other mercury compounds to their patients well into the twentieth century. The following is an excerpt on the pharmacological uses of calomel from the 1911 edition of the *Encyclopedia Britannica*:

"Calomel possesses certain special properties and uses in medicine. . . . Calomel exerts remote actions in the form of mercuric chloride. The specific value of mercurous chloride is that it exerts the valuable properties of mercuric chloride in the safest and least irritant manner, as the active salt is continuously and freshly generated in small quantities. . . .

"Externally the salt [calomel] has not any particular advantage over other mercurial compounds. . . . Internally the salt is given in doses—for an adult of from one half to five grains. It is an admirable aperient [laxative], acting especially on the upper part of the intestinal canal, and causing a slight increase of intestinal secretion. The stimulant action occurring high up in the canal (duodenum and jejunum), it is well to follow a dose of calomel with a saline purgative a few hours afterwards. . . .

"The salt [calomel] is often used in the treatment of syphilis, but is probably less useful than certain other mercurial compounds. It is also employed for fumigation; the patient sits naked with a blanket over him, on a cane-bottomed chair, under which twenty grains of calomel are volatilized by a spirit-lamp; in about twenty minutes the calomel is effectually absorbed by the skin." [224]

Mercurochrome

The antiseptic mercurochrome is still sold in pharmacies in many countries and is applied to cuts and wounds to prevent infections. This antiseptic is marketed under many other names including Merbromine, sodium mercurescein, Asceptichrome, Supercrome, Brocasept, and Cinfacromin. The commercial product usually contains 2 percent of the mercury/bromine compound merbromine (C20H-9Br2HgNa2O6) mixed with water or alcohol.

Mercurochrome is no longer sold in the U.S. retail market because of concerns about its mercury toxicity, but bulk quantities of merbromine can still be purchased from U.S. chemical supply houses. This mercury-containing antiseptic is

[223] "The History of Calomel as Medicine in America," The Weston A. Price Foundation, cited above.

[224] 1911 edition of the *Encyclopedia Britannica* entry on Calomel, http://www.1911encyclopedia.org/Calomel.

still widely sold and used for both human and veterinary applications in Australia and in most other countries.

What does the mercury treaty say about mercurochrome?

The mercury treaty lists topical antiseptics such as mercurochrome for phase out by 2020 under Article 4. Parties may seek an exemption from the phase out until 2030.

Mercury in Traditional Medicines

Cinnabar (a naturally occurring mineral that contains mercury sulfide) has been used in traditional Chinese medicine for thousands of years as an ingredient in various remedies. It is sometimes also called *zhu sha* or China Red. According to the *Pharmacopoeia of China*, forty cinnabar-containing traditional medicines are still in use there. One study suggests that because cinnabar is insoluble in water and poorly absorbed in the gastrointestinal tract, it exhibits less toxicity than other forms of mercury, although long-term users may suffer kidney disorders. Nonetheless, the study's authors indicate that the rationale for the continuing inclusion of cinnabar in traditional Chinese medicines remains to be fully justified.[225] An Internet site selling *zhu sha* as a medicinal makes the claim that it tranquilizes the mind and treats irritability, insomnia, and dreaminess as well sore throat and canker.[226]

In the past, calomel was also used in traditional Chinese medicine, but these uses have largely been replaced by safer therapies. No calomel-containing oral Chinese remedy is today listed in the Pharmacopoeia of China.[227]

There is a long tradition of ingesting mercury for medicinal purposes in Indian Ayurveda practice and in tantric and Siddha alchemy. Vagbhata, who lived in the sixth century C.E., recommends internal uses of mercury for therapeutic ends. The Italian traveler Marco Polo, who visited India in the late thirteenth century, reportedly met yogis who lived long and healthy lives because they consumed a drink made of mercury and sulfur. Indian traditional medicines called *kajjali* and *rasasindoor*, which contain mixtures of mercury and sulfur, are still used to treat diabetes, liver disease, arthritis, and respiratory diseases.[228]

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225 Jie Liu et al., "Mercury in Traditional Medicines: Is Cinnabar Toxicologically Similar to Common Mercurials?" *Experimental Biology and Medicine*, 2008, http://ebm.rsmjournals.com/cgi/content/full/233/7/810.

226 Cinnabar (Zhu Sha), TCM China, http://www.tcmtreatment.com/herbs/0-zhusha.htm.

227 Jie Liu et al., "Mercury in Traditional Medicines," cited above.

228 Ayurveda Under the Scanner, *Frontline*, April 2006, http://www.thehindu.com/fline/fl2307/stories/20060421004011200.htm.

Reportedly, mercury capsules known as *azogue* are still sold in Mexico in religious stores for use as a remedy for indigestion or gastroenteritis blockages (*empacho*).[229]

What does the mercury treaty say about mercury in traditional medicines?

The mercury treaty excludes mercury added products used in traditional or religious practices from the phase out requirements of Article 4 that applies to most other mercury added products.

Thiomersal

Thiomersal, which goes by the name thimerosal in North America, is a mercury-containing compound that is used to prevent bacterial and fungal growth. Other names for this compound include Merthiolate, mercurothiolate, ethylmercurithio-salicylic acid, and sodium 2-ethylmercuriothio-benzoate. The chemical formula for thiomersal is $C_9H_9HgNaO_2S$.[230]

Thiomersal is widely used in vaccines and may also be used in some other medical applications such as skin tests, eye and nose drops, and multiple-use solution containers such as those used for contact lenses. It also may be used in tattoo inks.[231] In the United States, manufacturers of contact lens solutions voluntarily discontinued the use of thiomersal in these products before 2000. This practice, however, may continue in other countries.

Thiomersal is sometimes present in waste streams from hospitals, clinical laboratories, and pharmaceutical industries, and this may lead to the need for environmental cleanups.[232]

The use of thiomersal in childhood vaccines has become a subject of controversy.

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229 "Cultural Uses of Mercury," UNEP Mercury Awareness Raising Package, http://www.chem.unep.ch/mercury/awareness_raising_package/G_01-16_BD.pdf.

230 "Exposure to Thimerosal in Vaccines Used in Canadian Infant Immunization Programs," Public Health Agency of Canada, 2002, http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/02vol28/dr2809ea.html.

231 Wikipedia entry on thiomersal, http://en.wikipedia.org/wiki/Thiomersal.

232 "Treatment Technologies for Mercury in Soil, Waste, and Water," U.S. EPA Office of Superfund Remediation and Technology Innovation, cited above.

THIOMERSAL IN VACCINES

Some vaccines do not contain thiomersal. These include many single-dose vaccines and vaccines for which the thiomersal might interfere with the vaccine's efficacy. In some vaccines, thiomersal is used during the production process but is not added to the final product. These vaccines typically contain trace amounts of thiomersal of less than 0.5 micrograms per dose. Some other vaccines contain thiomersal that has been added to the final product to prevent contamination with microorganisms. These vaccines typically have thiomersal concentrations of between 10 micrograms and 50 micrograms per dose.[233]

Thiomersal is sometimes added to vaccines during manufacture to prevent microbial growth. However, with changes in manufacturing technology, the need to add preservatives during the manufacturing process has decreased. Thiomersal is added to multi-dose vials of vaccines to prevent the vaccines from becoming contaminated with pathogens when multiple needles are inserted into the same container. For example, there is a case from before vaccines contained preservatives in which vaccinated children died after being injected with a vaccine contaminated with living staphylococci bacteria. A British Royal Commission investigated the incident and recommended that biological products in which the growth of a pathogenic organism is possible should not be issued in containers for repeated use unless there is a sufficient concentration of antiseptic (preservative) to inhibit bacterial growth. The use of a preservative in multi-dose vaccines is now the internationally accepted practice.[234]

In the late 1990s, in response to a new legislative mandate and parental concerns, the U.S. Food and Drug Administration began an investigation of thiomersal in vaccines. The FDA found that by the age of 6 months, an infant in the U.S. might have received as much as 187.5 micrograms of mercury from thiomersal-containing vaccines. In 1999, in response to these findings, the U.S. Centers for Disease Control and Prevention (CDC) and the American Academy of Pediatrics (AAP) issued a joint precautionary statement. They asked pharmaceutical companies to remove thiomersal from vaccines as quickly as possible and, in the interim, they asked doctors to delay the birth dose of hepatitis B vaccine in children who were not at risk for hepatitis.[235]This statement was based on precaution and evidence that methylmercury and many other mercury compounds were documented neurotoxins. At the time, however, there had been few if any relevant studies of ethyl mercury and no studies that indicated harm to infants caused by exposure to thiomersal in vaccines.

In 1999, the European Agency for the Evaluation of Medicinal Products (EMEA) also issued a statement about thiomersal in childhood vaccines. The EMEA concluded that there was no evidence of harm to children caused by the level of thiomersal in the vaccines then being used. The EMEA, however, also called for precautionary action such as promoting the general use of vaccines without thiomersal and other mercury-containing preservatives and working towards the elimination of these preservatives by manufacturers.[236]

233 "Thiomersal and Vaccines: Questions and Answers," World Health Organization, 2006, http://www.who.int/vaccine_safety/topics/thiomersal/questions/en/.

234 "Thimerosal in Vaccines," U.S. Food and Drug Administration, http://www.fda.gov/BiologicsBloodVaccines/SafetyAvailability/VaccineSafety/UCM096228#thi.

235 Paul A. Offit, "Thimerosal and Vaccines—A Cautionary Tale," *The New England Journal of Medicine*, 2007, http://www.nejm.org/doi/full/10.1056/NEJMp078187,

236 Gary L. Freed et al., "Policy Reaction to Thimerosal in Vaccines: A Comparative Study of the United States and Selected European Countries," Gates Children's Vaccine Program, http://www.path.org/vaccineresources/files/thimerosal_decision.pdf.

Since 1999, controversy about thiomersal in vaccines has continued and escalated. Many parents believe that infant exposure to thiomersal in vaccines contributes to autism and other brain-development disorders. This appears to have been driven in part by dramatic increases in the incidence of autism in the 1980s and 1990s. In addition, a growing awareness that mercury is a serious neurotoxin has made many parents question why any mercury should be injected into their infants. Parents' groups and others cite studies in the literature that they claim support or suggest a connection between thiomersal and autism. These claims, however, are disputed.[237]

The medical community broadly rejects the conclusion of a connection between thiomersal and childhood neurological disorders. In 2004, the U.S. Institute of Medicine's Immunization Safety Review Committee issued a report examining the hypothesis that vaccines are causally associated with autism. It concluded that the body of evidence favors rejection of a causal relationship between thimerosal-containing vaccines and autism.[238] Also in 2004, the European Medicines Agency Committee for Human Medicinal Products concluded that the latest epidemiological studies show no association between vaccination with thiomersal-containing vaccines and specific neurodevelopmental disorders.[239] The position of the U.K.'s Commission on Human Medicines is that there is no evidence of neurodevelopmental-adverse effects caused by the levels of thiomersal in vaccines except for a small risk of hypersensitivity reactions such as skin rashes or local swelling at the site of injection.[240] The World Health Organization's Global Advisory Committee on Vaccine Safety has concluded that there is currently no evidence of mercury toxicity in infants, children, or adults exposed to thiomersal in vaccines.[241]

The importance of vaccination for the prevention of disease is well documented. Concerns about the side effects of vaccinations have, in some developed countries, resulted in a reduction in the vaccination rate, and this has contributed to outbreaks of measles and other diseases in addition to an increase in serious complications. There are, therefore, important concerns within the public health community and elsewhere that controversies about thiomersal in vaccines could have serious consequences for children's health.

Many industrial countries appear to be moving toward the use of single-dose vaccines and are phasing out thiomersal in vaccines. Doing this globally may take time because of challenges associated with replacing multiple-dose vaccines with single-dose vaccines. There are also challenges with changing the formulation of a licensed vaccine. Replacing thiomersal with a mercury-free alternative during production or not adding thiomersal to the final product will generally require research and development and will also require a new licensing process with a series of preclinical and clinical trials.[242] Still, progress has been made.

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237 Wikipedia entry on thiomersal controversy, http://en.wikipedia.org/wiki/Thiomersal_controversy.

238 "Thimerosal in Vaccines," U.S. Food and Drug Administration, http://www.fda.gov/biologicsbloodvaccines/safetyavailability/vaccine-safety/ucm096228.htm.

239 Thiomersal– Frequently Asked Questions, Irish Health Protection Surveillance Centre, http://www.ndsc.ie/hpsc/A-Z/VaccinePreventable/Vaccination/Thiomersal/Factsheet/File,3948,en.pdf.

240 "Thiomersal (Ethylmercury) Containing Vaccines," U.K. Medicines and Healthcare Products Regulatory Agency, 2010, http://www.mhra.gov.uk/Safetyinformation/Generalsafetyinformationandadvice/Product-specificinformationandadvice/Thiomersal%28ethylmercury%29containingvaccines/index.htm.

241 "Thiomersal and Vaccines: Questions and Answers," World Health Organization, cited above.

242 Ibid.

According to a fact sheet from a European NGO coalition, the National Central Laboratory of the Danish Health System has not used thiomersal in vaccines for children since 1992. Sweden's Children's Vaccine Program has not used mercury-based preservatives in vaccines since 1994. And the U.K. Department of Health announced in 2004 it would no longer use thiomersal in infant vaccines.[243] In the United States, almost all routinely recommended vaccines for infants are available only as thiomersal-free formulations or in formulations that contain less than 1 micrograms of thiomersal per dose. The only exception is inactivated influenza vaccine, which is mainly available for pediatric use in the U.S. in a formulation that does contain thiomersal. However, some other formulations of this vaccine that contain either no thiomersal or only a trace of thiomersal are also available.[244]

The situation in the developing world is quite different, with little apparent momentum in most countries toward phasing out thiomersal from vaccines. In many countries, it is difficult or impossible to mobilize the resources necessary to immunize all infants and children, and this has raised questions about diverting resources to the phaseout of thiomersal vaccines. Substitution of thiomersal-containing vaccines with mercury-free alternatives might be particularly problematic in countries where domestically manufactured vaccines contain thiomersal and are far less costly than imported thiomersal-free substitute vaccines.[245]

Another important consideration is whether vaccines used for immunization are supplied in single-dose vials or multiple-dose vials. In many cases, it is important for multi-dose vials to contain a preservative like thiomersal to protect against contamination from the multiple needles entering the vial. The use of a preservative is less important when a single-dose vial is used. The WHO argues that supplying vaccines in single-dose vials would require a significant increase in production capacity and would come with a high cost. The WHO also indicates that single-dose vials require significantly larger cold storage space and they increase transportation needs. Because the WHO has determined that many developing countries have insufficient production capacity and insufficient infrastructure for vaccine transportation and storage under cold-chain conditions, it has concluded that additional costs and burdens make single-vial dose vaccines unfeasible for the majority of countries.[246,247]

Even though the WHO and some others make a strong case against moving to eliminate thiomersal in the developing world, many NGOs and civil society organizations are uncomfortable with this as a long-term perspective. They are aware that the global medical community has often been slow to recognize harm to human health from low-dose exposures to other toxic substances. For example, as recently as the 1960s, the medical community did not yet have studies or data clearly showing that children with blood lead levels as high as 50 micrograms per deciliter were suffering harmful lead poisoning. Today, it is recognized that children with blood lead levels of 5 micrograms per deciliter or less suffer harmful effects. With this historical perspective in mind, some find it difficult to take comfort in assurances from the medical community that there is no known association between thiomersal-containing vaccines and neurodevelopmental harms to children.

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243 "Mercury and Vaccines Fact Sheet," Stay Healthy, Stop Mercury Campaign, 2006, http://www.env-health.org/IMG/pdf/Mercury_and_vaccines.pdf.

244 "Thiomersal and Vaccines: Questions and Answers," World Health Organization, cited above.

245 Mark Bigham, "Thiomersal in Vaccines: Balancing the Risk of Adverse Effects with the Risk of Vaccine-Preventable Disease," *Drug Safety*, 2005, http://adisonline.com/drugsafety/pages/articleviewer.aspx?year=2005&issue=28020&article=00001&type=abstract.

246 "Thiomersal and Vaccines: Questions and Answers," World Health Organization, cited above.

247 "WHO Informal Meeting on Removal of Thiomersal from Vaccines and Its Implications for Global Vaccine Supply," 2002, http://www.aapsonline.org/iom/who.pdf.

As many highly industrial countries move toward phasing out thiomersal from childhood vaccines, it is difficult for many NGOs and others to accept the double standard that this should not also be a goal for developing countries. Possible ways forward might include research into effective mercury-free preservatives that replace thiomersal and assistance to vaccine manufacturers in developing countries to enable them to produce good, low-cost, mercury-free vaccines.

What does the mercury treaty say about thiomersal?

The mercury treaty specifically excludes vaccines containing thiomersal as preservatives (also known as thimerosal) from the phase out requirements of products containing mercury under Article 4.

8.12 MERCURY IN CULTURAL PRODUCTS AND JEWELRY

Mercury is widely used in cultural and religious practices. In Hindu practice, mercury is contained in *parad*, a material from which religious relics are made. It is used in the rituals of several religions in Latin America and the Caribbean including Candomblé, Espiritismo, Palo Mayombé, Santería, Voodoo, and Yoruba Orisha. It is also used in medicines and jewelry and for other cultural practices.[248]

People may keep mercury in containers, such as pots or cauldrons, to purify the air. In some cultures, people sprinkle mercury on the floor of a home to protect its occupants. Some use it with water and a mop to spiritually clean a dwelling. And some add mercury to oil lamps and candles to ward off evil spirits; to bring good luck, love, or money; or to hasten other spells. People also keep mercury in amulets, ampoules, vials, or pouches that they carry or wear around the neck.[249]

Parad is an amalgamation of mercury and other metals that is used to make relics for worship in the Hindu tradition. It is traditionally made of silver and mercury, but it is now often made of mercury and tin, with trace amounts of other metals. One study found the mercury content of Parad to be almost 75 percent. Various religious objects are made of Parad and sold in markets in India including beads worn around the waist or neck, cups used to ritually drink milk (*amrit*), statues that represent Gods (*Shivlings*), and other objects. India has many Shiva temples which have Parad Shivlings. A study by Toxics Link, an Indian NGO, found that mercury leaches from Parad into milk, and this may expose those who follow the

248 D.M. Riley et al., "Assessing Elemental Mercury Vapor Exposure from Cultural and Religious Practices," *Environmental Health Perspectives* 109, no. 8, 2001, p. 779-84, http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1240404&tool=pmcentrez&rendertype=abstract.

249 "Cultural Uses of Mercury," UNEP Mercury Awareness Raising Package, cited above.

tradition of drinking milk from a Parad cup or drinking milk in which a Parad relic has been soaked.[250], [251]

Mercury has also been used in western works of art. The most famous of these is the Calder Mercury Fountain in the Fundación Joan Miro museum in Barcelona, Spain. The Spanish Government commissioned the American artist Alexander Calder to build this fountain as a monument to the Almadén mercury mine for display at the 1937 World's Fair. Instead of using water, the fountain pumps and circulates approximately five metric tons of pure elemental mercury. The fountain is placed behind glass to protect viewers from touching the mercury or breathing its fumes.[252]

Mercury jewelry that may have been originally produced for use as amulets or charms sometimes finds its way onto the general market. For example, mercury-containing necklaces thought to come from Mexico began to show up in schools in the U.S. and possibly elsewhere. One report describes necklaces with a beaded chain, cord, or leather strand and a glass pendant containing between three grams and five grams of mercury. The mercury is visible as a silvery clump of liquid rolling around in a hollow glass pendant. The glass pendants came in various shapes, such as hearts, bottles, saber teeth, and chili peppers, and sometimes the pendants also contained brightly colored liquid along with the mercury.[253], [254]

What does the mercury treaty say about mercury in cultural products and jewelry?

Article 4 of the mercury treaty specifically excludes any restriction on the use of mercury in religious and traditional practices and these products are not subject to phase out.

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250 Ibid.

251 "Mercury: Poison in Our Neighbourhood," Toxics Link, 2006, http://www.toxicslink.org/mediapr-view.php?pressrelnum=30.

252 Calder Mercury Fountain, Atlas Obscura, http://atlasobscura.com/place/calder-mercury-fountain-fundacio-joan-miro.

253 "School Health Alert About Mercury in Necklaces," Oregon State Government Research & Education Services, 2009, http://www.oregon.gov/DHS/ph/res/mercalert.shtml#look.

254 Mercury Legacy Products: Jewelry, NEWMOA, http://www.newmoa.org/prevention/mercury/projects/legacy/novelty.cfm.

9. INTENTIONAL SOURCES: MERCURY IN MINING AND INDUSTRIAL PROCESSES

There are three major mining and industrial processes that intentionally use mercury and release large quantities into the environment. These are artisanal and small-scale gold mining (ASGM), the use of mercury catalysts in chemicals production and mercury-cell chlor-alkali plants.

9.1 MERCURY USE IN ARTISANAL AND SMALL-SCALE GOLD MINING (ASGM)

ASGM is the highest source of mercury releases to air along with coal burning. Every year it is estimated that approximately 727 tons of mercury are released to air from ASGM, accounting for more than 35 percent of total anthropogenic emissions.[255] Small-scale gold miners purchase and use elemental mercury, which is then released into the environment during the gold extraction process. Of all the intentional uses of mercury, artisanal and small-scale gold mining is the largest global source of mercury pollution to all media. This practice also does serious harm to miners, their families, and communities surrounding the hotspots areas and severely degrades local and regional ecosystems.

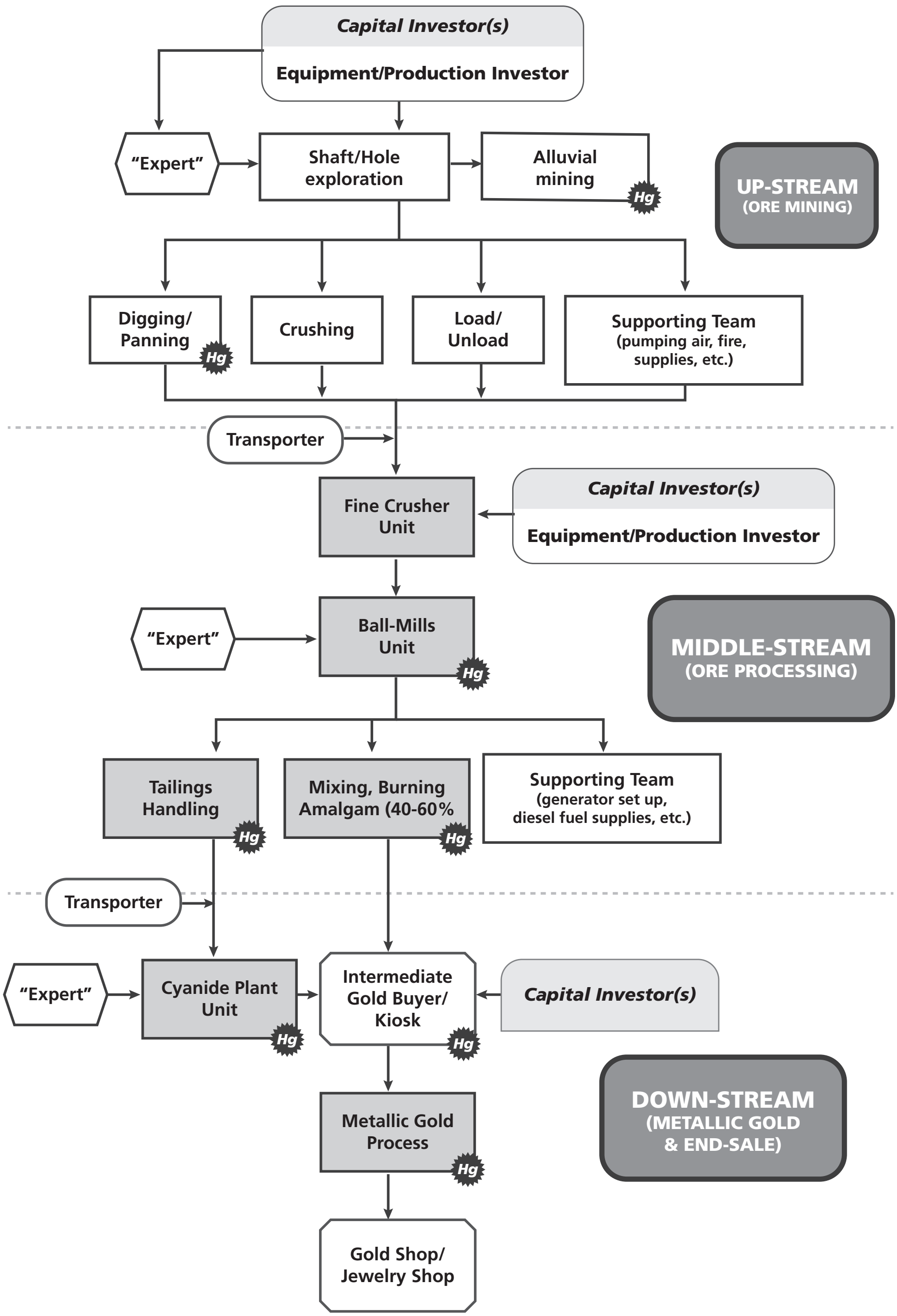
Mercury used at every stage of ASGM

Mercury is used at many points throughout the various processes that make up ASGM, but most people handling and disposing of mercury in ASGM processes have little or no understanding of its human health impacts or potential for environmental contamination. In general terms the processes of ASGM can be divided into upstream, midstream and downstream processing – all with opportunities to use mercury.

Upstream level activities are mainly related to the primary mining in the underground shaft, or panning the alluvial type of ore along the river bank or in the middle of the water body; rough crushing activities; and transporting the ore to the processing plants (the mid-stream level). In some alluvial gold ore areas, miners do not need to use mercury at all as the gold dusts or nuggets are easy to find. However, in some alluvial areas where the gold concentration are not that high,

[255] UNEP (2013) UNEP Global Mercury Assessment 2013, p.ii

THE HIERARCHY OF ASGM PROCESSING



miners mine or dredge the ores from the bottom of the river and process the ore in sluice boxes with mercury above the river. The end-result is primarily a gold purity of approximately 20-60 percent..

Mid-stream level activities are concerned mostly with ore and gold processing. These activities include transporting the ore from the mining site to the fine crushing plant or directly to the processing plant; chemical mixing; water and wastewater management; tailing handling and transporting; and power generation and amalgam burning in order to reach 20-60 percent gold purity (in some places up to 80 percent). In most reef or rock type of ore, the gold extraction process takes place in ball-mill plants or cyanide leaching plants. Depending on the ore, 100 to 500 grams of mercury will be added into every ball-. Water usage in this processing plant is quite excessive and in many places undermines the agriculture or fisheries sector leaving the agricultural land and the fish ponds - even the river - dry

Downstream level activities deal with pure metallic gold processing to get 99.99 percent gold purity as precious metal using aqua regia and borax, and silver as the by-product. At this stage, the end-sale of gold at the local level will be at the gold kiosks or simple gold shops or individual gold buyer, and abandoned mercury-contaminated sites. The activities involved in this stage are gold purity testing, amalgam burning, chemical mixing, gold and silver ingot/nugget production, and business transactions.

Poverty, crime and ASGM

It important to recognize from the outset that the vast majority of ASGM miners live in marginalized impoverished circumstances and are struggling to create livelihoods for themselves and their families. Many live in remote areas with little or no access to alternative employment opportunities and have limited to no access to education or health care. For those on the frontline of ASGM the work is isolated, uncontrolled, dangerous and often comes with meager rewards- with many miners working off debts to those higher up the gold trade chain who have access to capital and invest in the trade.

Typically, gold mining operates in boom and bust cycles, with discoveries of gold, potentially large migrations of ASGM miners, intense mining and environmental damage, including a long legacy of mercury contamination. When the gold-based economic boom runs out, there is often an economic bust leaving environmental damage, and very few economic opportunities. In the meantime the gold rush moves to areas of new discoveries and the process repeats itself.

The gold trade itself often operates, at least in part, illegally and often in the realm associated with organized crime and criminal network activities such as drug trafficking and prostitution. As a result, normal standards of occupational health and safety rarely apply and scenarios considered unacceptable in normal employment – such as child labor and economic servitude -- are rife. Communities caught up in an ASGM gold rush often experience negative social impacts such as an influx of prostitution (including child prostitution), heightened conflict and violence, and an escalation in alcohol and drug abuse.

When attempting to develop solutions to mercury use in ASGM, policies must recognize the role that poverty plays and the lack of options available to many of those who take part in this activity. When presented with the option of exposure to toxic mercury that will damage health in the long term or not being able to feed your family today, most choose the former option. Developing economic alternatives, ridding ASGM of mercury and protecting communities from the criminal structures involved in ASGM are objectives that must be pursued concurrently to reduce the human and environmental impacts of ASGM.

ASGM expansion driving mercury demand

When gold prices are rising, the demand for gold and investment into ASGM increases as well. The price of mercury can also increase due to high gold demand but is also dependent on local and global mercury supply levels. When demand is high for mercury but supply is low (because of hording, bans or legal restrictions) mercury prices rise and vice versa. In the recent past elemental mercury traded at ASGM sites were claimed to have 99.99 percent purity and came predominantly from USA, Germany, Spain, and China.

Since the recent bans on mercury exports from the U.S. and EU, and the closure of the Spanish mercury mines, it is less clear who the major suppliers of mercury to the ASGM sector are. However, Singapore and Hong Kong have emerged as the largest exporters of mercury to countries with a significant ASGM sector according to data from the *UN Comtrade* database. This database records imports and exports of mercury including source and destination countries. Ironically, the database also reports that Japan is a significant exporter of mercury to countries engaged in ASGM. Another major global exporter of mercury is Kyrgyzstan which has significant reserves in its Khaidarkan mine. This is the last known primary mercury mine in the world outside of China (which appears to be a net importer of mercury) and international bodies such as the UN are negotiating with Kyrgyzstan to reduce its output[256]. The international trade in mercury can be difficult to

[256] UNEP/UNITAR (2009) Khaidarkan Mercury: Addressing Primary Mercury Mining in Kyrgyzstan.

decipher as mercury may be bought and sold numerous times before it reaches its destination and this can obscure the true origins of the shipments some of which may be illegal.

At the local level, mercury is traded freely in ASGM sites in portions (inside small plastic bags of 100 gram, or half a small bottle weighing 500 gram or in flasks of 34.5 kg). Moreover, most mercury is traded illegally, secretly, brought in by the gold buyers or the financiers as part of the working capital.

UNEP estimates that small-scale gold mining is practiced in 77 countries with about 20 million people worldwide directly engaged, and another 85 to 90 million people indirectly dependent upon it[257] of which about 20-30 percent are women and children. Globally, small-scale miners produce between 20 percent and 30 percent of all gold that is mined—approximately 500 to 800 metric tons of gold per year. Combined output in mature mining operations fell in 2009 and mining operations are shifting to Africa and central Asia where artisanal and small-scale practices are most prevalent.[258] These regions are the least explored or exploited due to the poor capacity and investment climate in the past.[259] Moreover, known large gold deposits are relatively depleted. Most of the remaining gold deposits now exist as traces buried in remote corners of the globe, under indigenous peoples' territory, national parks, and/or protected forest, which leads to shallow mining activities.[260]

The devastation of these areas for gold mining adds an extra layer of environmental impacts to ASGM operations with a clear link between mining, deforestation, habitat destruction and reduced biodiversity. There are also clear environmental justice issues as conflict increases between indigenous people trying to protect their traditional lands and ASGM miners.

Large scale mining operations are seen to be shifting the size of their operations into medium scale mining companies and are moving to regions least explored or exploited in the past, where it is cheaper to mine (i.e. lower labor costs) and environment and social costs not always taken into account. This is where artisanal and small-scale mining hotspots are created and are most prevalent.[261]

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257 UNEP, 2013. Global Mercury Assessment.

258 UNEP, 2011. Environment for Development Perspectives: Mercury Use in ASGM.

259 *Financial Times*, 12 November 2010. World Economy: In Gold they Rush.

260 Larmer, 2009. The Real Price of Gold. National Geography.

261 *Financial Times*, 2010, cited above.

PRODUCTION OF GOLD FROM ASGM

These mining operations are frequently illegal or unregulated, and the miners are typically poor and often have little or no awareness of the hazards posed by mercury exposure.[262] (UNEP, 2008. Mercury Use in Artisanal and Small-Scale Gold Mining. UNEP Mercury Awareness Raising Package.) In some countries, the gold production from artisanal and small-scale gold mining operations attributed from 8 up to 75 percent of the national gold production. For example, in the Philippines, 75 percent of all mined gold is conducted by individuals and small gold operators (UNEP 2008 cited above). In most countries, gold production from ASGM sector is not recorded and not detected. In the Philippines gold from ASGM sites should be sold to the Central Bank, while in Ethiopia, gold should be sold to the National Bank of Ethiopia (NBE). Moreover, in Ethiopia, if miners organize themselves into cooperatives the gold will be purchased by the NBE at a 5 percent higher rate than the global market price.

Human exposure to mercury in ASGM

It is estimated that artisanal and small-scale gold mining operations consume between 650 and 1,000 metric tons of mercury each year. Some of this mercury is released directly into the air, especially from the amalgam burning process to get the gold. The rest is lost through spills, careless handling, and by other means, and the mercury ends up contaminating soils and released directly into water systems thereby entering the food chain. Mercury-contaminated soils can also run off into water systems. The result is widespread methylmercury contamination in ecosystems surrounding artisanal and small-scale mining activities. The elemental mercury that is present in contaminated soils or in water systems can subsequently volatilize into the air, contribute to global atmospheric mercury and contaminate the food chains (i.e. in fish and rice).[263],[264] Already many people around ASGM sites have elevated levels of mercury in the blood, hair, urine, breast milk, as mercury has contaminated the food chain.[265]

Health surveys have found elevated levels of mercury in hair, blood, and urine of many miners and communities in ASGM hotspots.[266] Some miners have been exposed to levels of mercury more than 50 times higher than WHO public-exposure

262 Evers, D.C., et.al. 2013. Global mercury hotspots: New evidence reveals mercury contamination regularly exceeds health advisory levels in humans and fish worldwide. Biodiversity Research Institute. Gorham, Maine. IPEN. Göteborg, Sweden. BRI-IPEN Report 2013-01a. 20 pages.

263 BaliFokus, 2013. Mercury Hotspots in Indonesia. ASGM sites: Poboya and Sekotong in Indonesia IPEN Mercury-Free Campaign Report.

264 Krisnayanti, et.al. 2012. Environmental Impact Assessment. Illegal/Informal Gold Mining in Lombok. GIZ.

265 Ibid.

266 Ibid.

limits. At one site, nearly half of all miners exhibited unintentional tremors, a typical symptom of mercury-induced damage to the central nervous system. Miners' families often live nearby the locations where amalgam is heated. Miners also carry mercury home with them on their contaminated clothes. As a result, miners' families are also frequently exposed.[267] It is reported that in Indonesia, and likely elsewhere, health care officials often have low awareness about mercury poisoning, and they may interpret tremors and other symptoms of mercury exposure as malaria or dengue fever.[268]

Mercury contamination at artisanal gold mining sites is often ignored because these sites are frequently in remote areas far from the public's notice. Even when there is a desire to monitor these sites, it may be difficult to do so because of the unavailability of mobile equipment and local environmental laboratories. However, the mercury contaminated sites and gold rush ghost towns need serious attention as they still evaporate mercury into the atmosphere, contaminating the ground water and surface water bodies as well as threatening the sustainability of biodiversity and environmental services. The mercury-contaminated sites created by ASGM are expensive and difficult to clean up leaving an environmental legacy that can last for decades.

THE CONTAMINATED 'ECO PARK' OF MINAMATA

Lessons learned from the Minamata tragedy tell us that we should not wait for 20 years to manage the contaminated sites as the cost of inaction increases over time.

In Minamata, Japan, a large dump site containing mercury waste from acetaldehyde production by Chisso Corporation still dominates a large area on the shores of the bay adjacent to the town. Chisso and the government agreed to manage the contaminated site by establishing an 'Eco Park' in an attempt to cap and contain the mercury contamination. The site looks like a pleasant local park with landscaped grass and vegetation. However just beneath the surface lies thousands of cubic meters of mercury contaminated waste. The landscaping acts as a 'cap' over the waste dump while large engineered steel tubes act as 'walls' under the surface to hold back the waste. It has only a short life span before it will begin to leak mercury contamination again. This type of approach is not practical or feasible at ASGM sites and is an expensive temporary measure.

There is no quick or easy way to eliminate or minimize mercury emissions from small-scale gold mining. Solutions often are dependent on the region, area, or even locality where the mine is located. Many countries have attempted to outlaw

267 Ibid.

268 WHO, 2012. Exposure to Mercury: a Major Public Health Concern.

the practice, but the usual result is the creation of illegal mining operations. It has been reported that in a country where the practice of heating amalgam outdoors to recover gold was outlawed, some miners began heating the amalgam inside their homes and seriously exposed their entire families to mercury vapors. In Kalimantan, Indonesia, in 2007, a number of people were heating amalgam inside homes and gold shops without proper ventilation.

An intervention by the United Nations Industrial Development Organization (UNIDO) Global Mercury Project helped to remedy this with the installation of ventilation hoods.[269] A field assessment by UNIDO found that effective retorts can be produced for as little as U.S.D 3.20. Theoretically these tools can capture more than 95 percent of the mercury vapor and allow it to be recycled and reused 4-5 times before eventually the mercury becomes degraded. Unfortunately, because of the relatively low cost of elemental mercury, low awareness of the hazards from mercury vapors, and insufficient information about retorts, few small-scale miners use them.[270] At a pilot project in Peru, a retort and fume hood was introduced in gold shops and showed good results. However, in Central Kalimantan's gold market, where the same type of tools are installed in almost all shops, the mercury concentration in the market areas were quite high, more than 45,000 nanograms/m3.[271]

What does the mercury treaty say about ASGM?

The mercury treaty makes some important contributions to potentially reducing mercury releases from small-scale gold mining. It controls some aspects of mercury supply and trade, which may raise the price and restrict the availability of elemental mercury to small-scale miners. The ban on the use of mercury from primary mining and the closure of mercury cell chlor-alkali plants takes large volumes of mercury out of the supply chain. However, there are many other sources from which mercury can be obtained (such as metal recyclers and industrial scrubbing operations) and which are legal to trade for the purposes of ASGM, which is defined as an 'allowed use' under the mercury treaty.

Restricting the supply and increasing the price of mercury will discourage inefficient mining practices such as whole-ore amalgamation. Other technologies that capture gold using less mercury or no mercury, on the other hand, will become much more attractive to miners. Where governments concede that they have significant levels of ASGM activity, Article 7 of the mercury treaty requires a Na-

269 U.S. Agency for Toxic Substances and Disease Registry (ATSDR), 2012. Action Levels for Elemental Mercury Spills.

270 Private correspondence with an Indonesian NGO leader.

271 IPEN, 2013. The New Mercury Treaty: 3 Things That Need to Happen Now.

tional Action Plan (NAP) to address and reduce the use of mercury in ASGM (see below).

The NAP requires strategies to prevent foreign and domestic supplies of mercury being diverted into ASGM, thereby providing a mechanism to restrict mercury supply that is not controlled under primary mining or chlor-alkali closure provisions of the Treaty. A NAP can also help mobilize resources to provide better services and training to small-scale miners and their communities and to promote the adoption of less polluting and more sustainable practices. It can promote assistance to local governments in the mining areas particularly for improving health training to identify mercury related illness and better health facilities.

A NAP can help make financial support opportunities available to groups of miners willing to undertake cooperative operations that use non-mercury technologies or less polluting practices. The eventual phase out of the use of elemental mercury in mining practice should remain a long-term goal. The achievement of this goal, however, must be linked to successes in other poverty-reduction programs and, in some cases, displaced miners and their families may need access to supplemental livelihood opportunities.

Article 7 Artisanal and small-scale gold mining (ASGM)

- The objective is to "take steps to reduce, and where feasible eliminate, the use of mercury and mercury compounds in, and the releases to the environment of mercury from, such mining and processing." The ASGM activity is defined as, "mining and processing in which mercury amalgamation is used to extract gold from ore."
- It applies to countries that admit that ASGM is "more than insignificant."
- ASGM is an allowed use under the treaty. This qualifies it for mercury trade without any specific import limits – either in quantities or in time. Note: in some countries (or parts of countries), such as Indonesia, Malaysia, and the Philippines, the use of mercury in ASGM and mining is already prohibited. These and other countries that have already prohibited the use of mercury in mining and ASGM should strengthen their commitment to prohibiting trade of mercury for this use as well.
- According to the trade provisions (Article 3) mercury from primary mercury mines and chlor-alkali facilities cannot be used for ASGM after the treaty enters into force. Monitoring measures and public participation can help insure that this provision is enforced.
- If the country notifies the Secretariat that Article 7 applies to it (by indicating that the activity is "more than insignificant"), then it is required to develop a

national action plan and submit it to the Secretariat by three years after entry into force with a review every three years.

- Plan requirements include a national objective and reduction target, and actions to eliminate the following worst practices: whole ore amalgamation; open burning of amalgam or processed amalgam; amalgam burning in residential areas; and cyanide leaching in sediment, ore, or tailings to which mercury had been added without first removing the mercury. Countries should work to establish a sunset date or reduction target in their national objectives.
- Other plan components include steps to facilitate formalization or regulation of ASGM; baseline estimates of amounts of mercury used in the practice; strategies for promoting the reduction of emissions and releases of and exposure to mercury; strategies for managing trade and preventing the diversion of mercury into ASGM; strategies for involving stakeholders in the implementation and continuing development of the national action plan; a public health strategy on the exposure of ASGM miners and their communities to mercury, including the gathering of health data, training for health-care workers, and awareness-raising through health facilities; strategies to prevent the exposure of vulnerable populations, particularly children and women of child-bearing age, especially pregnant women, to mercury used in artisanal and small-scale gold mining; strategies for providing information to ASGM miners and affected communities; and a schedule for implementation of the national action plan. Note: while cleaning up the mercury-contaminated sites is not included in the treaty text, the proposed action plan can include this important component of addressing mercury pollution.
- Optional activities include the "use of existing information exchange mechanisms to promote knowledge, best environmental practices and alternative technologies that are environmentally, technically, socially and economically viable."
- Although mercury use is allowed for the ASGM sector, there is no phase-out date for ASGM in Article 7. In addition, ASGM is not covered by Article 5 (mercury added-processes). However, countries can establish phase-out dates in their national action plans and address ASGM in other articles as described.

USING YOUR NATIONAL ACTION PLAN TO CUT MERCURY IN ASGM

Paragraph 1f in Annex C on the ASGM national action plan states that in their national action plan, countries are required to include a section on "strategies for managing trade and preventing the diversion of mercury and mercury compounds from both foreign and domestic sources to use in artisanal and small scale gold mining and processing."

NGOs can use the mercury treaty to campaign on mercury use in the ASGM sector

Identifying the scale of ASGM activity

A key opportunity for NGOs is to demonstrate that ASGM is occurring at a 'significant' level. This is critically important because the 'threshold' for action on ASGM in the mercury treaty occurs when a country acknowledges that the extent of ASGM in their country is "more than insignificant". Unfortunately, the mercury treaty does not define 'significant' by gold production volumes, land areas impacted, mercury volumes consumed, miner numbers or other related metrics. Nevertheless, NGO's can and should make the case to their governments that ASGM activity is significant based on data, footage, case studies and anecdotal evidence.

A rapid assessment of the ASGM activity can be conducted using mercury import statistics and trade in your country derived from news clippings, reports, publications and observations. A number of indicators of significant ASGM activity are outlined below:

- Mercury import-export statistics. If your country imported more than 5 metric tons per year of mercury (refer to import code HS 280540) and you have no chlor-alkali or VCM industries, that amount might indicate the existence of ASGM activities.
- ASGM activities in more than one site in a region - you can identify the locations from media clippings, interviews, observations, etc.
- More than 1,000 people, miners and workers involved in ASGM activities at one period of time.
- Large amounts of mercury being used and the free trade of mercury.
- Wide spread environmental pollution and environmental damage.
- Evidence from health workers and communities of mercury impacts from ASGM to women, children and people's health.

- ‘New’ diseases identified in some ASGM areas.
- More than one casualty at ASGM a year; conflict or tension escalating for more than one year in a locality.

In some cases ASGM may be operating partially or wholly illegally in a particular locality, and governments may not always have accurate information on the extent of the activity. However, NGOs often have access to ‘on the ground’ information through their networks that may provide a more accurate assessment of the scale of ASGM in a particular region or country. If NGOs can work cooperatively with government agencies to record the extent of ASGM activity it becomes more difficult for governments to claim they have no evidence that ASGM activity is “more than insignificant.”

Undertaking environmental and biomarker mercury sampling

NGOs can also undertake mercury sampling to highlight to the government and the public that ASGM is contributing to mercury pollution in a particular area. Sampling can be undertaken in a number of different ways depending on the aspect of ASGM that an NGO may wish to highlight.

Sampling of soil or sediment (from streams or rivers) can confirm that environmental mercury contamination from ASGM activities is occurring and build the case with government that its impacts are ‘significant’. Sampling of mercury emissions in ASGM sites especially in the processing areas (middle-stream) involving sluice boxes, ball-mills and or cyanide leaching plants will show the mercury level in the air (indoor and outdoor) and confirm the route of mercury exposure through the air and inhalation. When the national standard is not available, it is important to use an internationally recognized environmental standard. For example the indoor air mercury standard, usually WHO standard or U.S. Department of Health and Human Welfare standard of 1,000 nanograms/m^3 can be used as the reference standard. WHO also provides fact sheets and guidance for public and decision makers on the impact of mercury to public health.[272]

Monitoring can also be conducted by taking biomarker samples of human hair, urine, blood, nails and food sources such as fish and rice to demonstrate that mercury from ASGM activity is entering the local food chains and impacting human health. WHO safe level standards for mercury in biomarker samples are widely used as references.

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272 http://www.who.int/mediacentre/factsheets/fs361/

This information can then be used to demonstrate to authorities that they have significant ASGM activity if they do not already recognize it. Even if governments accept they have a significant ASGM sector, this type of information is invaluable for public awareness raising and increased profile for the issue in the media. Environmental and health related monitoring data can also serve as an input to a National Action Plan in establishing baselines for the elimination and phase-out of mercury use and impacts in ASGM affected communities and the country's hotspots.

A recent collaborative project by IPEN and the Biodiversity Research Institute (BRI) used biomonitoring activities to highlight human health impacts of mercury from ASGM. The study investigated mercury levels in the hair of ASGM miners in Tanzania and Indonesia. At the two sites in Tanzania, Matundasi and Makongolosi, two-thirds of the hair samples exceeded the U.S. EPA mercury reference dose of 1 part per million (ppm) with levels in most miners 2-3 times the reference dose. The samples taken from ASGM workers in Sekotong and Poboya, Indonesia showed similar results among 19 out of the 20 individuals sampled. These sorts of results can be used to highlight to government and the media the scale and impacts of ASGM activity.

Monitoring international mercury trade

As mentioned above, it is critical to monitor the mercury imports for your country using customs import codes. The import code for mercury is HS 280540. If it is difficult to access import data in your country, you can check the online UN database for global trade known as UN Comtrade (http://comtrade.un.org/).

The international mercury trade is notoriously difficult to control

Monitoring the international trade codes for mercury provides some information about the scale of mercury imports into your country. However mercury smuggling and poor border controls can result in much higher levels of mercury entering your country than can be seen from the official domestic records. That is why it is very important to compare domestic import statistics for mercury with global export statistics that list your country as the recipient of the mercury.

The Indonesian government has recently announced that tracking mercury imports into the country has become impossible due to smuggling, vast coastlines and high demand for mercury use in the ASGM sector. The international records show hundreds of times more mercury entering Indonesia than has been recorded at the ports by Indonesian customs officials.

MERCURY SMUGGLING INTO INDONESIA

Rasio Ridho Sani, the Deputy Minister of Environment for Hazardous Substances stated, "I do believe there are a lot of illegal imports, but I don't know how much."

Mr. Rasio said he could not explain Singapore government export figures showing 291 metric tons, or more than 640,000 pounds, of mercury being sent legally to Indonesia in 2012, given that he personally signed mercury import requests. Those requests totaled less than one metric ton imported from anywhere in 2012.

Of the 368 metric tons of mercury exported to Indonesia in 2012, most — 291 tons — left from docks in Singapore, which is Indonesia's neighbor and a major mercury re-exporter. That year, according to United Nations statistics, Singapore exported a total of 478 metric tons of mercury.

Mr Rasio added, "If we can limit the mercury illegally coming into Indonesia, the price will increase," he said. "And when the price increases, gold dealers will look for alternatives" like cyanide or borax, which are also toxic but pose far fewer local and global health and environmental hazards.

Source: *The New York Times*, "Mercury Trade Eludes International Controls"
By Joe Cochrane Published: January 2, 2014

Monitoring Domestic supply (stockpiling)

If your country has chlor-alkali plants using mercury cell processes or primary mercury mining, your NGO could monitor these mercury sources to ensure the mercury is not diverted to ASGM uses. Chlor-alkali plants are converting to mercury-free processes around the world but there are still a significant number of plants that use the old mercury based process. When these plants are shut down or converted to mercury-free processes, the mercury stockpile that remains can be several hundred metric tons or more per facility depending on whether or not the plant maintained large stockpiles to replace the mercury lost under normal operations. Governments that are a party to the mercury treaty must prevent this mercury from being traded back into the supply chain and must direct mercury to a long-term mercury storage facility or permanently dispose of the mercury in an environmentally sound manner consistent with the requirements of the Treaty. NGOs should monitor the closure of these plants closely and ensure that all of the mercury is accounted for and dealt with according to the Treaty requirements.

For further information on how the mercury treaty addresses *mercury supply and trade* see section 7 of this booklet.

Developing a database of ASGM mercury contaminated sites for the NAP

National Action Plans (NAP) are required if a government identifies that ASGM is occurring at "more than significant" levels. So, while the cleanup of mercury contaminated sites is a voluntary measure under the mercury treaty, contaminated site remediation is included as a requirement of the NAP. Therefore, once the threshold requiring a NAP is met, NGOs can then campaign for a contaminated site remediation requirement to be included as a part of the plan. Remediation of these contaminated sites will generate more mercury that should be prevented from re-entering the supply chain and sent for long-term storage or environmentally sound disposal.

NGOs can also advocate for the need to create a mercury releases inventory as the baseline for the development of the sectorial NAPs that can be integrated into the National Implementation Plan. The mercury releases inventory can operate independently or in conjunction with a national Pollutant Release and Transfers Register (PRTR) that deals with a broader range of pollutants. This type of inventory can assist in assessing the size of mercury contamination issues in a country and the causes of it.

Advocating for Mercury Interim Storage and Long-term Storage/disposal capacity

Whether you are campaigning to eliminate mercury use in ASGM, clean up contaminated sites or ensuring that mercury arising from a decommissioned chlor-alkali plant does not enter the supply chain, it is important to establish a dialogue with government about the adequacy of mercury storage and disposal for your country.

Under the treaty, interim mercury storage is identified as storage for elemental mercury, as a commodity, to be used in the process and products defined as a "use allowed" under the treaty, including in ASGM sector. The Conference of the Parties (COP) will provide further guidance on the criteria of the interim storage of mercury. Further, the long-term mercury storage under the treaty is identified as the long-term disposal of mercury and wastes containing mercury with the options ranging only between above-the-ground or under-the-ground facility. Due to the treaty's tight criteria, not every country will be suitable to have their own mercury long-term storage, and regional long-term mercury storage solutions have been discussed in recent years.

Problems have arisen in some countries with secure mercury storage. In one example mercury in medical devices (thermometers etc.) were banned, and a hospital stored large quantities of this equipment in unsecured conditions only to find it has later been stolen and the mercury presumably on-sold. Removing mercury from the supply chain can only be effective if the interim storage and disposal infrastructure is secure and environmentally sound. This activity should be a priority for governments to undertake before the treaty enters into force and NGOs should encourage their government to develop this capacity as soon as possible.

For more information on how the mercury treaty addresses *storage of mercury* and mercury *contaminated sites* see section 11.4 and section 11 of this booklet respectively.

9.2 INTENTIONAL INDUSTRIAL USES: CHLOR-ALKALI PRODUCTION, VCM AND MERCURY CATALYSTS

The mercury treaty addresses chlor-alkali production, vinyl chloride monomer production and other manufacturing processes intentionally involving mercury catalysts under *Article 5: Manufacturing processes in which mercury or mercury compounds are used*. Under Article 5 some intentional uses are to be phased out while others are to be restricted, including new processes. This section of the booklet examines two of the most intensive mercury polluting industries (chlor-alkali and VCM production) in detail followed by an analysis of how the mercury treaty addresses these intentional sources.

9.3 MERCURY IN CHLOR-ALKALI PRODUCTION

Chlor-alkali plants are industrial processes that use electrolysis to produce chlorine gas or other chlorine compounds, alkali (also known as caustic soda or sodium hydroxide) or sometimes potassium hydroxide and hydrogen gas. Some older chlor-alkali plants still use what is called a mercury-cell process, which is very polluting and releases large quantities of mercury into the environment.

These plants employ an electrolytic process in which electricity in the form of direct current (DC) is passed between electrodes that are in contact with a saltwater (brine) solution. The positively charged electrode called the anode is graphite or titanium; the negatively charged electrode called the cathode is a large pool of mercury that may weigh several hundred tons. When electrical current is passed across the electrodes, it creates chlorine gas at the anode, which is vented and collected. This also creates a sodium-mercury amalgam at the cathode. Subsequently, a reaction between the metallic sodium in this amalgam and water is induced to produce sodium hydroxide and hydrogen gas, which are both also removed for use.

Mercury-cell plants were the main commercial process used for the production of chlorine and sodium hydroxide beginning in the 1890s and lasting until the middle of the twentieth century. Some mercury cells are still in operation throughout the world, but most have been replaced with alternative electrolytic or other processes that do not use mercury. These alternative processes use what are called diaphragm cells or membrane cells. A major reason that many mercury-cell plants have been shuttered or converted to non-mercury processes is regulatory pressures based on findings that these plants produce substantial mercury emissions, that they also produce mercury wastewater discharges and mercury-contaminated solid wastes, and that areas around chlor-alkali plants have become highly contaminated with mercury.[273] Another reason for replacement is that diaphragm-cell and membrane-cell chlor-alkali plants are more efficient than mercury-cell plants.

In addition, the caustic soda and possibly the chlorine compounds produced by mercury-cell chlor-alkali plants are typically contaminated with mercury. Caustic soda is used in the production of food products such as corn syrup, and mercury has been found in both corn syrup on the market and also in food products that contain corn syrup. Under an agreement with the U.S. government, the U.S. chlorine industry in the United Sates voluntarily agreed to limit the amount of mercury in the caustic soda it sells to 1 percent or less.[274]

UNEP's "Global Atmospheric Mercury Assessment" estimates global mercury emissions from chlor-alkali plants to be 60 metric tons. "The Technical Background Report to Global Atmospheric Mercury Assessment" from UNEP, however, estimates that mercury-cell chlor-alkali plants consumed 492 metric tons of mercury in 2005. This reported total was distributed as follows:

[273] "Compliance with Chlor-Alkali Mercury Regulations, 1986-1989: Status Report," Environment Canada, http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=E7E0E329-1&offset=4&toc=show.

[274] Dufault, R., LeBlanc, B., Schnoll, R., Cornett, C., Schweitzer, L., Wallinga, D., et al. (2009). Mercury from chlor-alkali plants: Measured concentrations in food product sugar. *Environmental Health*, 8, 2.
"Study Finds High-Fructose Corn Syrup Contains Mercury," *Washington Post*, January 28, 2009, http://www.washingtonpost.com/wp-dyn/content/article/2009/01/26/AR2009012601831.html.

Region	Mercury Consumption in Metric Tons
European Union	175
CIS and Other European Countries	105
North America	60
Middle Eastern Countries	53
South Asia	36
South America	30
Others listed	33
Total	492

In the case of chlor-alkali plants, the annual mercury consumption is simply the amount of mercury that the plant loses over the course of the year. Plants lose much of this mercury directly to the air because the process generates heat and because regular maintenance practices include the opening and closing of cell containments. Some of this mercury is released into bodies of water or contaminates the land surrounding the plant. Other mercury lost through the process goes to landfills or to other disposal facilities. Some ends up in the products that are produced or becomes bound to metallic materials in the plant. Additionally, because elemental mercury is volatile, much of the plant's mercury that ends up in water, in contaminated soils, in landfills, and other disposal facilities subsequently volatilizes and enters the air.

Historically, the chlor-alkali industry has done a very poor job of accounting for and reporting on its annual mercury releases into the environment. Both the industry and its regulators have acknowledged that until recently, they had very little information on the quantities and pathways of mercury losses from mercury-cell chlor-alkali plants.[275] In recent years, however, some governments have exerted regulatory pressures on the chlor-alkali industry to begin phasing out mercury-cell plants and, in the interim, to do a better job of preventing environmental releases of mercury and also to more accurately account for the releases that do occur. Operators in some countries now report annually on their mercury consumption.

275 John S. Kinsey, "Characterization of Mercury Emissions at a Chlor-Alkali Plant," U.S. EPA, 2002.

MERCURY-CONTAMINATED SOILS FROM CHLOR-ALKALI PLANTS

Researchers tested mercury-contaminated samples of soil taken from mercury-cell chlor-alkali plants in Europe. One sample was of soil that had originally been excavated from under a plant's cell house and then stored outside for approximately three years. This sample was found to be contaminated with mercury at the concentration of 569 ppm (mg/kg). Another sample was taken of the upper soil layer in the vicinity of a mercury-cell chlor-alkali plant and was found to be contaminated with mercury at the concentration of 295 ppm (mg/kg).[276]

The authors of the study noted that elemental mercury has an extremely high affinity for organic matter and binds tightly to organic soils. They noted further, however, that mercury bound to organic soils can, nonetheless, still be emitted from the soil into the atmosphere, especially during periods of high temperature.

There are indications that the number of operating chlor-alkali plants in the world has continued to decline since 2005, but it has been difficult to find a listing of all mercury-cell chlor-alkali plants still in operation. An April 2010 European industry association statement indicates that 39 mercury-cell chlor-alkali plants remain in operation in fourteen European countries.[277] A 2009 fact sheet from a leading North American chlor-alkali operator states that approximately 13 percent of chlor-alkali products in North America come from mercury-cell plants.[278] A report by the World Chlorine Council (WCC) to UNEP indicates that in 2007, a total of 70 mercury-cell chlor-alkali plants were operating in the following countries: the United States, Canada, Europe, Russia, India, Brazil, Argentina, and Uruguay.[279] There are a number of other mercury-cell plants still operating in countries not covered by this WCC report, including plants possibly in some Middle Eastern countries, in some CIS countries other than Russia, and in some Asian countries other than India.

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276 Carmen-Mihaela Neculita et al., "Mercury Speciation in Highly Contaminated Soils from Chlor-Alkali Plants Using Chemical Extractions," *Journal of Environmental Quality*, 2005, http://www.ncbi.nlm.nih.gov/pubmed/15647556.

277 "Storage of Mercury: Euro Chlor View," Euro Chlor, cited above.

278 "Caustic Soda Production," Olin Chlor Alkali Products, 2009, http://www.olinchloralkali.com/Library/Literature/OverviewOfProcess.aspx.

279 "Number of Plants and Capacity of Mercury Electrolysis Units in U.S.A./Canada, Europe, Russia, India and Brazil/Argentina/Uruguay," submitted by the World Chlorine Council to UNEP, http://www.chem.unep.ch/mercury/partnerships/Documents_Partnerships/All_comments_Euro_Chlor.pdf.

What does the mercury treaty say about mercury-cell chlor-alkali plants?

The mercury treaty establishes a time schedule for the phase out of all mercury-cell chlor-alkali plants and requires that mercury recovered from those plants be kept off the market and put into long-term storage or treated for environmentally sound disposal.

9.4 MERCURY CATALYSTS USED FOR VCM AND OTHER CHEMICAL PRODUCTION

Mercury-containing catalysts have been used for many years in industrial chemical production. These catalysts remain in large-scale commercial use in the manufacture of vinyl chloride monomer (VCM), and this use appears to be growing. On the other hand, it appears that most other industrial uses of mercury-containing catalysts are declining or have been phased out.

As indicated above, the tragedy of Minamata disease was caused by a chemical plant that used mercury sulfate as a catalyst in the production of the chemical acetaldehyde. It appears that mercury catalysts are no longer being used in the industrial production of acetaldehyde.

Historically, organic mercury compounds were considered to be the catalysts of choice in the manufacture of polyurethane plastics and coatings in many applications. When mercury-containing catalysts are used for this purpose, mercury residues remain in the polyurethane.

MERCURY IN FLOORING CAUSED WIDESPREAD EXPOSURES

Between the 1960s and 1980s, many schools in the United States installed polyurethane flooring in their gymnasiums that typically contained between 0.1 percent and 0.2 percent mercury. One manufacturer alone claimed to have installed more than 25 million pounds (11.3 million kg) of this flooring material. The surface of this flooring slowly releases elemental mercury vapor, particularly from damaged areas. Officials have measured airborne concentrations of mercury in some school gymnasiums. One school district reported mercury vapor in the range of 0.79 micrograms to 1.6 micrograms of mercury per cubic meter of air in the breathing zone. Another school reported 0.042 micrograms to 0.050 micrograms of mercury per cubic meter of air. The variation in measurements may be attributed to the size of the floor, relative damage to the flooring material, ventilation in the gymnasium and the kind of environmental sampling equipment that was used.[280]

280 "Children's Exposure to Elemental Mercury: A National Review of Exposure Events," the U.S. Agency for Toxic Substances and Disease Registry, February 2009, http://www.atsdr.cdc.gov/mercury/docs/MercuryRTCFinal2013345.pdf#page=31.

Recently, alternative mercury-free catalysts for polyurethane production based on titanium, bismuth, and other materials appear to have largely replaced mercury catalysts for this use.[281] However, the extent to which mercury catalysts may still be in use for polyurethane manufacture in some countries or regions is not generally known.

Some other chemicals have also historically been manufactured using mercury catalysts such as vinyl acetate and 1-amino anthrachion.[282] It is possible that these and most other uses of mercury catalysts may have been globally discontinued, but this still needs to be verified.

Mercury catalysts, however, remain in large-scale commercial use in the manufacture of VCM, and this use appears to still be growing. VCM, whose chemical formula is C_2H_3Cl, is the main feedstock in the manufacture of polyvinyl chloride plastic (PVC), also known as vinyl. VCM is produced using acetylene (C_2H_2) as a raw material. The acetylene is combined with hydrogen chloride (HCl) and flows through a mercuric chloride catalyst to produce the VCM. VCM manufacture from acetylene and a mercuric chloride catalyst was in use in the United States as recently as 2000.[283]

The production of VCM in most countries does not use any mercury catalysts but instead uses a different manufacturing process. In most countries, acetylene is not used as the hydrocarbon feedstock in VCM production, but rather, ethylene is used. An important difference between these two feedstocks is that ethylene is produced from petroleum or natural gas while acetylene is produced from coal.

Until recently, the use of ethylene as the feedstock was considered to be the state-of-the-art process for VCM manufacture. However, as the prices of petroleum and natural gas have increased relative to the price of coal, the acetylene process has become more attractive. This is especially the case in countries such as China that must import petroleum but which have large coal reserves that are mined with low-cost labor. Another factor that has discouraged building new plants using ethylene as a feedstock is the wide fluctuations in the price of petroleum. Enterprises building PVC plants in northwest China near coal mines feel confident they

281 "Catalyst and Method of Making Polyurethane Materials," World Intellectual Property Organization, 2005, http://www.wipo.int/pctdb/en/wo.jsp?IA=GB2004005368&DISPLAY=DESC.

282 "Mercury Substitution Priority Working List," Nordic Council of Ministers, 2007, http://www.basel.int/techmatters/mercury/comments/240707hsweden-2.pdf.

283 Barry R. Leopold, "Use and Release of Mercury in the United States," for U.S. EPA, 2002, http://www.epa.gov/nrmrl/pubs/600r02104/600r02104prel.pdf.

can count on a steady supply of cheap coal at stable prices.[284] These considerations have not only led to the rapid growth of VCM plants using mercury catalysts in China, but they could also apply elsewhere and encourage the further expansion of this industry in other countries and regions.

Based on information provided to the NGO, Natural Resources Defense Council (NRDC), by the Chemical Registration Center (CRC) of China's State Environmental Protection Administration, total PVC production in China was 1.9693 million metric tons in 2002 and rose to 3.0958 million metric tons in 2004, with 62 PVC manufacturing facilities known to be using mercury catalysts.[285] Statistics by China Chlor-Alkali Industry Association show that by the end of December 2010, China had 94 PVC manufacturing enterprises, with a total capacity of 20.427 million tons per year.[286] In 2012, the output volume of PVC totaled 13.181 million tons in China and is expected to continue to grow until 2017[287]. By the end of 2010, the scale of calcium carbide process-based PVC plants had made up 80.9 percent of gross domestic capacity.[288]

The catalysts used in the plants are in the form of activated carbon that has been impregnated with mercuric chloride. When the catalysts are installed, they are between 8 percent and 12 percent mercuric chloride. Over time, however, the catalyst is depleted and the amount of mercuric chloride in the catalyst decreases. When the amount drops to about 5 percent, the catalyst is replaced. The fate of the mercury that is lost from the catalyst is not well understood.[289]

According to CRC estimates, the amount of mercury present in catalysts that were used and subsequently replaced in 2004 was 610 metric tons. These spent catalysts were sent to recyclers, who processed them and were able to recover approximately 290 tons of elemental mercury.[290] This suggests that in 2004, the

284 "The Renaissance of Coal-Based Chemicals: Acetylene, Coal-to-Liquids, Acetic Acid," Tecnon OrbiChem Seminar at APIC, 2006, http://www.tecnon.co.uk/gen/uploads//syezuu55kgu0ok55epcqomjf12052006115942.pdf.

285 "NRDC Submission to UNEP in Response to March 2006 Request for Information on Mercury Supply, Demand, and Trade, http://www.chem.unep.ch/mercury/Trade-information_gov_stakeholders.htm.

286 Foreign Economic Cooperation Office, Ministry of Environmental Protection of the People's Republic of China (2011) R&D Progress of and Feasibility Study Report on Mercury-free Catalyst in China

287 China Polyvinyl Chloride Market (PVC) 2013 Analysis & 2017 Forecasts in New Research Report at ChinaMarketResearchReports.com

288 Foreign Economic Cooperation Office, Ministry of Environmental Protection of the People's Republic of China (2011) R&D Progress of and Feasibility Study Report on Mercury-free Catalyst in China

289 NRDC (2006)

290 Ibid.

manufacture of VCM in China resulted in as much as 320 metric tons of mercury losses to the environment. The Chinese government estimated that at PVC production of 8 million tons in 2010, mercury catalyst and mercury used in the industry amounted to about 9,600 tons and 781 tons respectively.[291] On this basis it is estimated that at least 800 metric tons of mercury is consumed each year and must be replaced.[292]

The international community currently has no data on the mercury emissions from VCM plants that use mercury catalysts or from the recycling facilities that process their spent catalysts. Because the experts who prepared the report had no reliable emissions data to work with, UNEP's "Global Mercury Assessment 2013" treats VCM plants as if they release zero mercury emissions into the atmosphere. This means that the UNEP estimate of 1,930 metric tons of total global anthropogenic mercury emissions per year from all sources does not count any emissions associated with VCM manufacturing as part of the total. The information that is available is of great concern. A report by The China Council for International Cooperation on Environment and Development[293] predicted that by 2012, China's VCM/PVC production would reach 10 million metric tons with associated mercury consumption exceeding 1000 metric tons. The reality is that 13 million metric tons were produced in 2012 and PVC production is planned to double between 2010 and 2020. There has also been conflicting reports as to whether mercury from these catalysts is recycled, with the most recent reports suggesting it is recycled.[294]

Because VCM production in China using mercury catalysts appears to be expanding, it is likely that unreported mercury losses from VCM manufacture will grow with time. In addition, if the VCM manufacturers that use mercury catalysts are able to achieve significant savings in their feedstock costs compared with VCM manufacturers who do not use mercury catalysts, this might over time create market pressures on manufacturers in other countries to convert from PVC manu-

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291 Foreign Economic Cooperation Office, Ministry of Environmental Protection of the People's Republic of China (2011) R&D Progress of and Feasibility Study Report on Mercury-free Catalyst in China

292 Zero Mercury Working Group INC 2 Briefing Paper Series Mercury in VCM and PVC Manufacturing

293 CCICED, 2011. Special Policy Study on Mercury Management in China. China Council for International Cooperation on Environment and Development (CCICED) Annual General Meeting. Online at: http://www.cciced.net/encciced/policyresearch/report/201205/ P020120529368288424164.pdf

294 AMAP/UNEP, 2013. Technical Background Report for the Global Mercury Assessment 2013. Arctic Monitoring and Assessment Programme, Oslo, Norway/UNEP Chemicals Branch, Geneva, Switzerland. vi + 263 pp. page 26

facturing using petroleum and natural gas as feedstocks to the possibly less costly acetylene/mercuric chloride manufacturing process.

What does the mercury treaty say about manufacturing processes in which mercury is intentionally used - such as chlor-alkali and VCM?

The mercury treaty takes a range of approaches to manufacturing processes that intentionally use mercury under Article 5. Industrial processes that are subject to prohibition or regulation are listed on Annex B of the mercury treaty. Parties can propose additional processes that use mercury to be added to the Annex B list five years after the treaty comes into force, in approximately 2023.

The treaty's approach to different industrial processes is either complete 'phase-out' over time or 'regulation and restriction,' which includes commitment to using less mercury within the industrial process. Certain provisions within Article 5 also allow new facilities to be established which use mercury in industrial processes after the Treaty enters into force. Restricted processes allow for continued use of mercury without a phase-out date.

Phased out: Chlor-alkali plants and acetaldehyde production

The strongest approach has been with chlor alkali production and acetaldehyde production (using mercury as a catalyst), which is subject to phase-out by 2025 and 2018 respectively although further concessions and extensions under Articles 5 and 6 of the Convention extend this deadline to 2035 and 2028 respectively. Note also that under Article 3 of the mercury treaty (Mercury supply sources and trade) that the large inventories of mercury associated with decommissioning chlor-alkali plant (up to several hundred metric tons) are not permitted to be redirected into the mercury trade and supply chain for any use and must be subject to environmentally sound disposal as outlined in Article 11. Some NGO groups have already experienced success in negotiating early closure of certain chlor-alkali plants through monitoring and campaigning. (see example below).

Restricted Processes: sodium or potassium methylate or ethylate and polyurethane

These processes use mercury-based catalysts and other mercury as part of their production. The mercury treaty regulated these processes in a number of ways but does not name a phase-out date. One requirement for these processes is that Parties are to reduce mercury per unit production by 50 percent in 2020 compared to 2010 use, but the calculation only applies to each individual facility. This allows new facilities to be established which may result in an overall increase in mercury emissions.

The mercury treaty also states that Parties should “aim” for these processes to be “phased out as fast as possible” and “within 10 years of the entry into force of the Convention”. These processes are also prohibited from using fresh mercury from primary mercury mining and must conduct research into mercury-free catalysts. Mercury use in these processes will be prohibited 5 years from the time the COP has established that a suitable mercury-free catalyst is available.

Restricted Processes: Vinyl Chloride Monomer (VCM)

VCM production has proven to be a significant mercury release problem, particularly in China where production is based on a unique method using coal and a mercury catalyst, whereas VCM in other countries is based on an ethylene feedstock. The ethylene method is mercury-free yet still very dirty because it creates and releases other serious environmental pollutants such as dioxins. The rapid growth in Chinese coal-based VCM production is highly problematic as it is likely to be releasing very high levels of mercury into the atmosphere due to the size of the industry.

The mercury treaty addresses this issue by prioritizing research and development into mercury-free catalysts for coal-based VCM production under Article 5. Mercury will also be prohibited from use in VCM manufacture five years from the date that the COP establishes that a suitable mercury-free catalyst is available. VCM plants are also required to reduce mercury per unit production by 50 percent in 2020 compared to 2010 use (i.e. increase the efficiency with which they use mercury).

More detail of the mercury treaty approach to manufacturing processes in which mercury is intentionally used is provided below.

Article 5 Manufacturing processes in which mercury or mercury compounds are used

- Phased-out processes using mercury include chlor-alkali production (2025) and acetaldehyde production using mercury or mercury compounds as a catalyst (2018).
- Note: Article 5 specifies that countries can apply for a five-year exemption to the phase-out date under Article 6, renewable for a total of 10 years, making the effective phase-out dates for the processes above 2035 and 2028 respectively.

- Restricted processes allow continued use of mercury with no current phase-out date. These include the production of VCM, sodium or potassium methylate or ethylate, and polyurethane. Note: VCM production does not appear in UNEP air emission inventories due to lack of data. VCM production using coal and a mercury catalyst is unique to China and a potentially enormous source of mercury releases.
- For VCM and sodium or potassium methylate or ethylate production, Parties are to reduce mercury per unit production by 50 percent in 2020 compared to 2010 use. Note: since this is calculated on a "per facility" basis, total mercury use and release can rise as new facilities are built.
- Additional measures for VCM include promoting measures to reduce use of mercury from primary mining, supporting research and development of mercury-free catalysts and processes, and prohibiting the use of mercury within five years after the COP establishes that mercury-free catalysts based on existing processes are technically and economically feasible.
- For sodium or potassium methylate or ethylate, Parties have to aim to phase out this use as fast as possible and within 10 years of entry into force of the treaty, prohibit the use of fresh mercury from primary mining, support research and development of mercury-free catalysts and processes, and prohibit the use of mercury within five years after the COP establishes that mercury-free catalysts based on existing processes are technically and economically feasible.
- For polyurethane, Parties are to aim "at the phase out of this use as fast as possible, within 10 years of the entry into force of the Convention." However, the treaty exempts this process from paragraph 6, which prohibits Parties from using mercury in a facility that did not exist prior to the date of entry into force. This implies that new polyurethane production facilities using mercury can be operated after the treaty comes into force for a Party.
- Parties have to "take measures" to control emissions and releases as outlined in Articles 8 and 9, and report to the COP on implementation. Parties have to try to identify facilities that use mercury for the processes in Annex B and submit information on estimated amounts of mercury used by them to the Secretariat three years after entry into force for the country.
- Exempted processes not covered by the article include processes using mercury-added products, processes for manufacturing mercury-added products, or processes that process mercury-containing waste.
- Parties are not allowed to permit the use of mercury in new chlor-alkali plants and acetaldehyde production facilities after the treaty comes into force (estimated to be approximately 2018).

- The regulated processes are the ones listed above (and in Annex B). However, Parties are supposed to "discourage" the development of new processes using mercury. Note: Parties can allow these mercury-using processes if the country can demonstrate to the COP that it "provides significant environmental and health benefits and that there are no technically and economically feasible mercury-free alternatives available providing such benefits."
- Parties can propose additional processes to be phased-out, including information on technical and economic feasibility as well as environmental and health risks and benefits.
- The list of prohibited and restricted processes will be reviewed by the COP five years after the treaty enters into force; this could be approximately 2023.

NGOs can make use of Article 5 of the mercury treaty to take action on intentional use of mercury in manufacturing processes.

Article 5 of the mercury treaty provides a number of opportunities for NGOs to tackle industries that use mercury in their processes. These include campaigning for currently 'restricted' processes to be added to the list of processes destined for 'phase-out' thereby securing more concrete time frames for a ban on specific activities. There are also actions that can be taken to convince national authorities to phase out processes earlier than stipulated in the mercury treaty.

Promote early phase-out of industrial processes using mercury

Parties to the mercury treaty are not obliged to wait until the deadlines for phase-out of industrial processes before taking action. National governments are free to act to close down these processes or restrict their use of mercury earlier than the treaty requires.

NGOs should promote early phase-out of these processes in their country wherever possible. Mercury-based chlor-alkali production is a prime example of a candidate for early phase-out. Not only do these plants consume large quantities of mercury in their operations, they also have large amounts of 'unaccounted for' mercury that most analysts conclude are lost to air as vapor at the plants. Some older plants even had unsealed floors where spilled mercury was allowed to drain into the soil. Each plant has a large inventory of mercury in storage to replace the mercury lost during production every year. In the past decommissioning of chlor-alkali plants led to hundreds of metric tons of elemental mercury being re-sold on the mercury supply market. In many cases this mercury was directed through intermediaries to ASGM operations around the world further contributing to uncontrolled mercury pollution. The mercury treaty prevents this form of trade when it comes into effect, and the mercury from decommissioned plants must be subject to environmentally sound storage/disposal.

Most mercury cell chlor-alkali plants are of older construction, and years of operation almost certainly have resulted in mercury contamination in and around the facility, including soil, built surfaces, vegetation and waterways (especially sediment). This contamination may also have impacted on human health and biota such as fish. Any waste dumps associated with the facility may also contain significant quantities of mercury.

NGOs can promote the early decommissioning of chlor–alkali plants (or conversion to mercury-free membrane chlor-alkali production) by highlighting the urgency of action through environmental monitoring that exposes mercury contamination. Demonstrating that human health and the environment are at risk from mercury at specific facilities can be a catalyst that environmental regulators and politicians react to and achieve earlier phase-out dates.

NGO CAMPAIGNS CAN ACCELERATE PHASE-OUT OF CHLOR-ALKALI PLANTS

Arnika Association, a Czech Republic based IPEN member group, was able to negotiate with Czech regional authorities for an early phase-out of that country's two contaminating, mercury cell chlor-alkali plants by undertaking activities to highlight the mercury pollution from this industry and by taking part in decision making process called "integrated pollution prevention and control permit". Arnika undertook a series of sampling activities in fish caught in Labe River (also known as the Elbe River in Germany) downstream from Spolana in Neratovice and Spolchemie in Ústí nad Labem to confirm whether use of mercury in these chlor-alkali plants resulted in food source contamination of fish.

The sampling confirmed serious environmental pollution with contamination of fish and river sediments. Elevated levels of mercury in air were also detected around the boundaries of the chlor-alkali plants. Joint publication of the sampling results by IPEN and Arnika resulted in considerable pressure on government regulators and the chlor-alkali industry to speed up the planned closure of the mercury processes. One chlor-alkali plant had intended to use mercury until 2020 but the high mercury contamination levels found in fish by Arnika resulted in agreement from the plant to cease mercury use by June 2017. Another chlor-alkali plant in Usti decided to commence conversion of its plant immediately with final deadline by the end of 2015.

Arnika also noted that the Czech Republic PRTR (Pollutant Release and Transfer Register) was very useful in identifying mercury releases and potential contaminated sites. Some countries have these registers under differing names (Australia has a National Pollution Inventory) and in most countries that have this type of register, the information is publicly available online. Arnika also identified the newly revised and strengthened Integrated Pollution Prevention and Control (IPPC) Directive of the European Commission as a tool whereby Best Available Techniques (BAT) could be imposed on chlor-alkali plants as part of their operating license to phase out use of mercury and/or to further drive down mercury and POPs emissions.

Targeting plants that rank high on the PRTR for mercury pollution

For those countries that have a Pollutant Release and Transfer Register (PRTR) NGOs can assess and identify which processes (not limited to VCM, chlor-alkali and other processes listed under Article 5) are releasing significant amounts of mercury to air, water or as waste transfers. This can be used as a tool for identifying sites that can be sampled for contamination or to highlight with authorities the worst players that should be targeted for mercury phase-out or tighter regulation.

E.U. NGOs have additional campaign tools

The European Commission has recently upgraded and strengthened its Industrial Emissions Directive (IED) and tightened the Best Available Technology (BAT) requirement for industrial processes using mercury. NGOs should campaign to ensure that the environmental license for individual facilities requires the plant to abide by the IPPC Directive and incorporate BAT into production methods as soon as possible. For chlor-alkali plants it is clear that membrane based technology (the choice for nearly all chlor-alkali conversions and upgrades) is BAT for this form of chemical production. Using these policy and regulatory tools will increase pressure on plants to move to mercury-free processes.

Monitoring for phase-out can work for all industrial processes using mercury.

While the examples provided above relate specifically to chlor-alkali processes, the same strategy can be used interchangeably for sodium or potassium methylate or ethylate, and polyurethane facilities. By making mercury contamination and poor management of mercury waste a public concern with human health implications, it is difficult for authorities to brush aside the issue. Contamination of the food and water supplies is a particularly sensitive issue and targeted testing of biota such as fish is an issue the public can relate to.

Even if local industrial regulation is weak highlighting the problems caused by specific facilities can result in political action or policies to clean up the rest of that industry in the country. Timing can also be very important. With many national election cycles operating on a 3-4 year basis there are opportunities to release mercury monitoring information and demand action just prior to an election when prospective political leaders are paying greater attention to the requests of constituents and can make commitments to further action.

10. UNINTENTIONAL MERCURY SOURCES – EMISSIONS AND RELEASES

Unintentional sources of mercury include burning, cleaning and refining fossil fuels, mining and refining metal ores, and the use of mercury-containing materials in high-temperature processes such as cement production and waste incineration. According to UNEP's estimates,[295] air emissions from these unintentional sources contribute more than 57 percent to total atmospheric global mercury emissions from all anthropogenic sources. The facilities that create this type of mercury pollution are often referred to as 'point sources'. Coal burning is the largest single contributor in this sector with 85 percent of total unintentional emissions releasing 475 tons of mercury to atmosphere annually. Contaminated sites have also been estimated to release up to 4 percent of total anthropogenic emissions of mercury to air, which translates to around 82 metric tons of mercury annually. The mercury treaty addresses emissions and releases from unintentional mercury sources under Article 8 and Article 9 of the treaty respectively.

Air Emissions (Article 8) and releases to land and water (Article 9)

The scope of Article 8 of the mercury treaty is to address large-scale industrial processes (point sources) that unintentionally release mercury in air emissions. This Article also includes mercury emissions to air from contaminated sites.

All of the unintentional sources described above also have the ability to release mercury to land and water, usually in the form of process wastes. IPEN played a key role in the negotiation of the mercury treaty ensuring that releases to water and land were given as much priority as releases to air. As a result the treaty now recognizes releases of mercury to land and water and list measures to address such releases in Article 9.

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295 UNEP, 2013. Global Mercury Assessment 2013, Sources, Emissions, Releases and Environmental Transport. UNEP Chemicals Branch, Geneva, Switzerland. p.9

What does the mercury treaty say about mercury emissions to air?

The objective of the mercury treaty in relation to air emissions is to control and reduce mercury emissions over time. The sources of emissions that are subject to treaty provisions are listed in Annex D and are currently limited to:[296]

- Coal-fired power plants.
- Coal-fired industrial boilers.
- Smelting and roasting processes used in the production of non-ferrous metals;
- Waste incineration facilities.
- Cement clinker production facilities.

The treaty imposes different requirements on point sources on the basis of whether they are 'new' or 'existing' facilities.

Existing facilities

For existing facilities Parties are required to take *measures* that will achieve reasonable progress in reducing emissions over time. At this point the treaty has left threshold limit values for mercury emissions from point sources to the discretion of the Party. If there is a commitment to develop threshold limit values it is anticipated that guidance will be developed for consideration at COP1.

Measures to reduce mercury emissions from existing sources must be undertaken as soon as possible but no later than 10 years after the treaty enters into force for that Party. These measures can take into account national circumstances, and the economic and technical feasibility, and affordability of the measures. Existing facilities can reduce emissions by using Best Available Techniques/ Best Environmental Practices (BAT/BEP) or can choose alternatives including:

- A quantified goal.
- Emission limit values.
- Multi-pollutant control strategy.
- Other alternative measures.

Reductions are to take place on a 'per facility' basis meaning that overall emissions may rise if there is an increase in the total number of facilities over time which would add to cumulative emissions.

[296] Other mercury point sources such as VCM and chlor-alkali plants are addressed separately under Article 5 of the mercury treaty.

Parties must also develop an inventory of point source mercury emissions (as listed in Annex D) as soon as possible and no longer than 5 years after the treaty enters in force for that Party.

New facilities

A new facility can either be a facility that is constructed one year after the Treaty enters into force for that Party or an existing facility that has been *substantially modified*[297] that is listed on Annex D.

New facilities (or sources) have stronger controls under the Treaty than existing sources. BAT/BEP must be implemented for new sources within 5 years of the Treaty entering into force for that Party. A Party can apply emission limit values instead of BAT/BEP for new sources as long as the same reductions are achieved. Parties can construct new sources without BAT/BEP requirements if they delay ratification of the Treaty.

Parties are also given the option of creating a National Action Plan (NAP) to address emissions to air for their country. If the Party chooses to adopt a NAP it must be submitted to the COP within 4 years of entry into force for that Party.

Article 8 Emissions (air)

- The objective is "controlling and where feasible reducing emissions of mercury and mercury compounds..." Note: emissions mean air emissions from point sources in Annex D and country discretion decides what is feasible.
- For existing sources, the objective of the article is "for the measures applied by a party to achieve reasonable progress in reducing emissions over time."
- Air emission sources included in the treaty are coal-fired power plants and industrial boilers; smelting and roasting processes used in production of non-ferrous metals (only lead, zinc, copper, and industrial gold); waste incineration; and cement clinker production facilities.
- Emission sources that were deleted from the treaty during negotiation were oil and gas; facilities in which mercury-added products are manufactured; facilities that use mercury in manufacturing processes; iron and steel manufacturing including secondary steel; and open burning.

[297] To "convert" an existing source to a new source through modification there must be a "significant increase in mercury emissions, excluding any change in emissions resulting from by-product recovery."

- Negotiators at INC5 did not find it necessary to set threshold limit values for emission sources, leaving the possibility to develop emission limit values at the discretion of the Parties.
- Preparing a national plan to control emissions is optional. If one is created, it is submitted to the COP within four years of entry into force for the Party.
- New sources have stronger control measures than existing sources.
- For new sources BAT/BEP is required to "control and where feasible reduce" emissions and BAT/BEP is to be implemented no later than five years after the treaty enters into force for that Party. Emission limit values can substitute for BAT if they are consistent with its application.
- If a government postpones ratification, then it has a longer window of time to construct new sources without requiring BAT/BEP.
- BAT/BEP Guidance will be adopted at COP1. Presumably an expert group will develop the guidance before then during intercessional periods between future INCs.
- A new source can be either new construction one year after entry into force for the country or a substantially modified facility within category sources listed in Annex D. The language specifies that to "convert" an existing source to a new source through modification there must be a "significant increase in mercury emissions, excluding any change in emissions resulting from by-product recovery." The Party gets to choose whether any existing source is subject to the more stringent requirements of new sources.
- Measures on existing sources are to be implemented as soon as practicable but no later than 10 years after the treaty enters into force for that Party.
- Measures on existing sources can take into account "national circumstances, and the economic and technical feasibility, and affordability of the measures."
- There is no requirement for an existing facility to apply BAT/BEP. Instead, countries can choose one item from a menu that includes a quantified goal (could be any goal), emission limit values, BAT/BEP, multi-pollutant control strategy, and alternative measures.
- All reductions are taken on a "per facility" basis, so an increased number of facilities will increase total mercury emissions.
- Parties have to establish an inventory of emissions from relevant sources (Annex D) as soon as possible and not later than five years after entry into force for the country.
- The COP has to adopt, as soon as possible, guidance on methods to prepare the inventories and criteria that Parties can develop to identify sources within a category.

- Parties have to report on their actions under this article according to the requirements in Article 21.

How can NGOs use the mercury treaty to campaign on unintentional mercury emissions to air?

Compiling inventories of known and suspected facilities

NGOs can immediately begin the process of cataloguing (and mapping) facilities that are of the type identified under Annex D of the Treaty. This database can then feed into the government inventory of known existing sources. These may be numerous as coal is burned in many types of industrial boilers other than power plants. These plants may not be the subject of regulation or licensing, and local knowledge that can be provided by NGOs may prove valuable in their identification and the development of inventories.

Push for the establishment of a PRTR

There is also a strong role for a Pollutant Release and Transfer Register (PRTR) in developing an inventory of industrial mercury sources. NGOs can advocate for the establishment of a PRTR (either for mercury alone or preferably for a range of criteria pollutants) where facilities identified on Annex D are required to report their mercury emissions annually to a public online database. This not only assists in developing a national inventory, but can be useful in assessing the potential mercury reductions from individual facilities (and the entire sector) over time. It can also be used as an audit tool to gauge whether 'existing' sources can be identified and considered for treatment as 'new' sources due to higher reported mercury emissions.

Campaign for BAT/BEP and world's strongest emission limits.

NGOs should push immediately for the most stringent emission limits that have been applied elsewhere in the world for these industries. Where possible emission limits should be applied in conjunction with BAT/BEP. Both of these requirements should be drafted into facility environmental licenses with penalties for non-compliance. Compliance should be determined by regular audits by independent environmental specialists. The process of developing BAT/BEP and emission limits does not need to wait until the treaty enters force and can begin immediately. If more stringent guidance is developed through the COP guidance process then national limits can be revised further downward and reflected in license conditions of facilities.

Early transition to lower mercury and mercury free energy sources.

NGOs can also campaign for coal-fired boilers to convert to less harmful fuel types. This can range from low mercury content coal (some coal deposits contain up to four times the concentration of mercury than other coal deposits) through to replacement with alternative energy sources such as solar, wind and wave energy.

What does the mercury treaty say about mercury releases to land and water?

Releases of mercury to land and water are a critical human health issue because most mercury impacts arise from eating mercury contaminated food – in particular fish that have elevated concentrations of methyl mercury. For mercury to become methylated it must first enter an aquatic environment where microorganisms convert it from other forms of mercury to highly bioavailable methyl mercury. It then biomagnifies through the aquatic food web reaching significant concentrations at higher trophic levels such as top predators (sharks, tuna etc) and ultimately humans.

Article 9 of the mercury treaty addresses releases of mercury to land and water with a similar objective to Article 8 – that is controlling and where feasible reducing mercury releases. Article 9 mirrors Article 8 in that it applies to point sources.

Article 9 details similar restrictions and options as those listed for air emissions in Article 8 such as:

- Applying release limit values, BAT/BEP, multi-pollutant control strategy, or alternative measures to reduce releases;
- Parties are to identify sources of releases as soon as possible but no later than 3 years after entry into force for that Party.
- Parties are to establish an inventory of releases from 'relevant'[298] sources as soon as possible but no later than 5 years after entry into force for that Party.

Parties are also given the option of creating a NAP to address releases to land and water for their country. If the Party chooses to adopt a NAP it must be submitted to the COP within 4 years of entry into force for that Party.

The COP is also to develop guidance as soon a practicable on BAT/BEP and a method for preparing an inventory of releases.

[298] 'relevant' sources are those that are identified by national governments as releasing 'significant' quantities of mercury

Article 9 Releases (land and water)

- The objective is "controlling and where feasible reducing emissions of mercury." Note: releases means mercury releases to land and water from point sources that are not covered in other provisions of the treaty. Country discretion decides what is feasible.
- Sources included in the treaty are defined by countries. During the negotiations, Annex G in the draft text contained a list of possible sources but negotiators deleted the annex at INC5 so that there are no guidelines for countries to know what sources might release mercury to land and water. Annex G contained the following sources: facilities in which mercury-added products are manufactured; facilities that use mercury or mercury compounds in the manufacturing processes listed in Annex D; and facilities in which mercury is produced as a by-product of non-ferrous metals mining and smelting.
- The article controls "relevant sources" – those are point sources identified by countries that release "significant" amounts of mercury.
- Preparing a national plan to control emissions is optional. If one is created, it is submitted to the COP within four years of entry into force for the Party.
- As for control measures, Parties are to apply one of the following "as appropriate": release limit values, BAT/BEP, multi-pollutant control strategy, or alternative measures.
- Parties are to identify sources of mercury releases to land and water no later than three years after entry into force for the country, and on a regular basis thereafter.
- Parties are to establish an inventory of releases from relevant sources as soon as possible and no later than five years after entry into force for the country.
- COP "as soon as practicable" is to develop guidance on BAT/BEP and a method for preparing inventories of releases.
- Parties have to report on their actions under this article according to the requirements in Article 21.

How can NGOs use the mercury treaty to obtain action on releases to land and water?

Push for an integrated PRTR

National governments should be convinced to include mercury in a PRTR along with other toxic substances. Any PRTR that is created should integrate air emissions, releases to land (including controlled an uncontrolled landfill sites) and waste treatment facilities, and releases to water. It is important that releases to all environmental media are considered to avoid creating data gaps in the PRTR where mercury contamination cannot be tracked and addressed.

Demand a National Action Plan for releases to air, water and land.

A NAP that only addresses air emissions or only addresses releases to land and water will be inadequate. NGOs should advocate for a comprehensive action plan that includes detailed accounts of how releases from point sources to land, air and water will be addressed including reduction targets and evaluation methods to track actual reductions (or increases) that occur.

Undertake sampling to identify unlisted sources

NGOs can undertake mercury sampling in soil, sediment and biota (such as fish) to identify facilities that may be releasing mercury but are not identified through other guidance. Human hair testing combined with biota testing can also provide a powerful tool to identify sources of mercury releases. The recent study by IPEN and the Biodiversity Research Institute[299] used this method to highlight mercury contamination and its impacts around the world from mercury hotspots. This approach can be adapted to sampling around sites that are suspected to release mercury.

10.1 COAL-FIRED POWER PLANTS

According to UNEP's "Global Mercury Assessment 2013" report, the second largest source of global anthropogenic mercury emissions to air is burning fossil fuels, especially coal. Fossil fuel burning accounts for 25 percent of anthropogenic mercury emissions to the atmosphere. In 2010 burning coal contributed 475 metric tons of mercury to atmosphere compared to 10 metric tons from all other fossil fuel sources. More than 85 percent of the mercury emissions in the coal sec-

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299 IPEN/BRI (2013)Global Mercury Hotspots: New Evidence Reveals Mercury Contamination Regularly Exceeds Health Advisory Levels in Humans and Fish Worldwide

tor are from coal fired power stations and industrial boilers.[300] New estimates of mercury emissions from residential and domestic coal burning have been revised downwards significantly to 2.9 percent of total mercury emissions for 2010 accounting for about 56 metric tons of mercury[301]. Mercury is present in coal in what is considered to be trace amounts, generally ranging from 0.01 mg to 1.5 mg of mercury per kilogram of coal (ppm).[302] However, the quantities of coal burned each year for electric power and for heating are so enormous that, according to UNEP estimates, in 2010, coal combustion from these sources released 474 metric tons of mercury emissions into the atmosphere.[303]

As a first approximation, the amount of mercury emissions released from a coal-fired power plant is related to the amount of coal it burns to generate a unit of electricity. Other things being equal, a more efficient power plant uses less coal to produce a kilowatt hour of electricity and thereby emits less mercury per unit of electricity than does a less efficient plant.

Increases in the efficiency of coal-fired power plants can be accomplished by measures such as improving or replacing burners, optimizing combustion, improving the efficiency of the boiler and heat transfer devices, improving plant operation and maintenance, and other measures. There have been claims that in some cases, these approaches can more than double power plant efficiency. A combination of economic factors and pollution-control regulations can also result in decisions to shutter old, inefficient power plants and industrial boilers and replace them with more efficient ones or with alternative energy sources.

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300 UNEP, 2013. Global Mercury Assessment 2013, Sources, Emissions, Releases and Environmental Transport. UNEP Chemicals Branch, Geneva, Switzerland. page 9

301 AMAP/UNEP, 2013. Technical Background Report for the Global Mercury Assessment 2013. Arctic Monitoring

and Assessment Programme, Oslo, Norway/UNEP Chemicals Branch, Geneva, Switzerland. vi + 263 pp. page20.

302 "Technical Background Report to the Global Atmospheric Mercury Assessment," AMAP and UNEP, cited above.

303 UNEP, 2013. Global Mercury Assessment 2013, Sources, Emissions, Releases and Environmental Transport. UNEP Chemicals Branch, Geneva, Switzerland. page 20

COAL COMBUSTION AND GREENHOUSE GAS EMISSIONS

Coal combustion also accounts for approximately 20 percent of all global greenhouse gas emissions.[304] Proposed measures to reduce coal combustion are currently being debated in the context of global intergovernmental negotiations to adopt a new climate-change treaty that will replace the Kyoto Protocol. In climate-change negotiations so far, the governments of several large countries have indicated an unwillingness to agree to binding measures that will significantly restrict their coal combustion. Some of them have cited an urgent need to greatly expand national electricity generation as an important part of their national economic-development strategies.

It was highly unlikely, therefore, that certain influential governments, who continue to oppose binding restrictions on coal combustion in the context of climate-change negotiations, would agree to similar binding restrictions on coal combustion during mercury-treaty negotiations

The mercury treaty negotiations, however, did create a second venue for high-profile international discussions about the harmful impacts of coal combustion, and they opened up additional opportunities for promoting energy efficiency and conservation together with the expansion of renewable energy sources.

To calculate the true costs of using coal-combustion technologies, one must incorporate into the cost equation its harms to the global environment and to human health. These include the mercury-related harms to human health and the environment addressed in this booklet. They also include harms associated with sulfur dioxide, nitrogen oxide, and numerous other toxic and hazardous pollutants released from coal plants. Finally, calculations of the true costs of using coal-combustion technologies must, of course, take into account costs associated with greenhouse gas emissions and climate change.

Efforts to phase out coal-combustion technologies will succeed when global mechanisms are in place to ensure that these and all the other external costs associated with coal combustion are internalized into the price of coal-derived energy. When this happens, it will become clear that energy-efficiency interventions and alternative-energy sources are actually less costly than coal technologies. Alternatives will then be able to quickly outcompete and replace coal.

Although the mercury treaty negotiations were not an alternate venue for negotiating climate change prevention measures, the negotiating process proved very useful in advancing public understanding and governmental recognition of the health and environmental costs associated with coal combustion. The mercury treaty has established binding measures that mandate governments—at least under some conditions and on some schedule—to require that new or existing power plants in their counties meet certain minimum-efficiency and/or pollution-control standards via BAT/BEP requirements. Higher pollution-control standards will generally increase costs. Finally, the mercury treaty establishes mechanisms for providing financial and technical assistance that support the implementation of its measures, and these might complement financial and technical assistance provided under an international climate-change regime.

[304] "Coal and Climate Change Facts," Pew Center on Global Climate Change, http://www.pewclimate.org/global-warming-basics/coalfacts.cfm.

Air pollution control devices (APCDs) that clean the flue gases of power plants can capture mercury and reduce emissions. The most common of these capture fly ash, the fine particles that rise with the flue gases. Some also capture acid gasses. APCDs include electrostatic precipitators, fabric filters, and flue gas desulfurization systems. Strategies for controlling mercury pollution should therefore include the use of new APCDs: Power plants should retrofit existing flue gas cleaning equipment to improve mercury capture and use additional flue gas cleaning devices. They should also employ techniques that can increase the mercury-capture efficiency of their existing APCDs.

The efficiency of mercury capture by APCDs is influenced by several factors. At the high temperatures of the combustion zones of coal-fired power plants, most of the mercury in the coal is released into the exhaust gas in the form of gaseous elemental mercury. This gaseous elemental mercury is not water soluble, and APCDs cannot easily capture it. Some of the elemental mercury, however, is oxidized by chemical reactions with other substances present in the flue gas. The oxidized mercury (often in the form of mercury chloride) is water soluble, and flue gas desulfurization systems can capture it. Oxidized mercury also has a tendency to associate with the particles in the flue gas and form particulate-bound mercury. Fabric filters and electrostatic precipitators can capture much of this particulate-bound mercury.[305],[306]

Depending on the relative proportions of elemental mercury, oxidized mercury, and particle-bound mercury in the flue gases—and depending on the effectiveness of the APCDs in use—the removal efficiency of mercury from flue gas reportedly ranges between 24 percent and 70 percent.[307]

The proportion of the elemental mercury in the flue gas that is converted into oxidized mercury and into particle-bound mercury depends on many factors, including the flue gas composition and the amount and the properties of the fly ash that is present. These factors, in turn, are dependent on the type and properties of the coal, the combustion conditions, and the design of the boiler and heat-extraction equipment. When coal has relatively high chlorine content, more of the elemental mercury in the flue gas tends to be oxidized; when coal has relatively low chlorine

305 S. X. Wang et al., "Mercury Emission and Speciation of Coal-Fired Power Plants in China," *Atmospheric Chemistry and Physics*, 2010, http://www.atmos-chem-phys.net/10/1183/2010/acp-10-1183-2010.pdf.

306 Charles E. Miller et al., "Mercury Capture and Fate Using Wet FGD at Coal-Fired Power Plants," U.S. Department of Energy, National Energy Technology Laboratory, 2006, http://www.netl.doe.gov/technologies/coalpower/ewr/coal_utilization_byproducts/pdf/mercury_%20FGD%20white%20paper%20Final.pdf.

307 S. X. Wang et al., "Mercury Emission and Speciation of Coal-Fired Power Plants in China," cited above.

content, less of the elemental mercury tends to be oxidized. Thus, measures that increase the amount of chlorine present in the process can, under some conditions, increase the mercury-removal efficiency of APCDs. Unfortunately, increased chlorine content in the flue gas can have the negative consequences of increasing the unintentional formation and environmental release of dioxins, furans and other persistent organic pollutants (POPs), which are also serious global pollutants. The Stockholm Convention on Persistent Organic Pollutants seeks to minimize and, where feasible, eliminate the formation and release of these POPs.

Additionally, unburned carbon in fly ash tends to absorb the mercury in the flue gas and create particle-bound mercury, much of which can be captured by APCDs. Some, therefore, support interventions that increase the amount of unburned carbon present in the fly ash with the intent of thereby increasing the mercury-removal efficiency of APCDs.[308] Such interventions, however, have the potential to reduce efficiency and increase risks from pollution caused by products of incomplete combustion. Finally, when coal-fired plants use selective catalytic reduction (SCR) to control releases of nitrogen oxide, this process also can convert elemental mercury to oxidized mercury and enhance mercury removal by APCDs.[309]

Several techniques that maximize the conversion of gaseous elemental mercury in the flue gas into oxidized mercury and/or particle-bound mercury have been recommended to optimize the capture of mercury using existing combustion and flue gas cleaning equipment. These techniques include the following:

Adding reagents to coal or to the high-temperature combustion gases to promote the oxidation of elemental mercury.

Modifying the combustion process to increase the amount or the reactivity of unburned carbon in fly ash to increase the adsorption of mercury and/or to promote the oxidation of elemental mercury.

Blending coal to change the composition of the flue gas and the properties of fly ash to increase the formation of oxidized and/or particulate-bound mercury.

Combining the above steps.[310]

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308 James Kilgroe et al., "Fundamental Science and Engineering of Mercury Control in Coal-Fired Power Plants," U.S. EPA, 2003, http://www.reaction-eng.com/downloads/Senior_AQIV.pdf.

309 Charles E. Miller et al., "Mercury Capture and Fate Using Wet FGD at Coal-Fired Power Plants," cited above.

310 James Kilgroe et al., "Fundamental Science and Engineering of Mercury Control in Coal-Fired Power Plants," cited above.

MERCURY IN WASTES RECOVERED FROM POLLUTION-CONTROL DEVICES

When power plants use APCDs to remove mercury from flue gases, there are concerns about the long-term fate of this mercury. Some of these wastes go to landfills or dumps where they have the potential to give off mercury air emissions or to leach mercury into surrounding soils and water systems. Some plants process wastes from control devices on-site, which can result in local environmental pollution and discharges of mercury into waterways. Much of these wastes, however, are recycled for use in the manufacture of construction materials and other uses.

According to an industry trade association and lobby group, the American Coal Ash Association, the sale and use of coal-combustion products is a multi-billion dollar industry. The association defines coal-combustion products as including power plant by-products such as fly ash, bottom ash, boiler slag, and various other residues from flue gas emission-control and desulfurization devices.[311]

Wastes from flue gas desulfurization systems (FGDs) can be recovered and used to produce synthetic gypsum. In the United States, for example, 75 percent of this waste is recovered and used. Most goes into making synthetic gypsum wallboard, a building material widely used in the inside of homes.[312] An average of about 8 tons of gypsum is present in the wallboards of a new U.S. home. As recently as 2001, 15 percent of the total gypsum supply in the U.S. came from coal wastes. By 2009, the use of gypsum derived from coal wastes more than tripled and now accounts for more than half the gypsum used in the U.S.[313] The U.S. Geological Survey (U.S.GS) estimates that 11 million tonnes of synthetic gypsum was consumed in the U.S. in 2011.[314]

Because FGDs operate at relatively low temperatures, studies have found that during their use, some volatile trace elements condense from the vapor phase and are removed from the flue gas. It has been suggested that FGDs may remove some gaseous elemental mercury from flue gas in this way.[315] This suggests, however, that elemental mercury may be present in the wastes from FGDs and has the potential for re-volatilization and release.

There is not much data on mercury releases from waste-derived synthetic gypsum, but the available data is troubling. Tests were done at a wallboard-manufacturing plant that uses wastes recovered from power plant FGDs. Researchers measured the mercury content of the incoming synthetic gypsum and the mercury content of the outgoing gypsum and calculated the mercury that is lost during the manufacturing process. A series of five tests were done on wallboard products that used synthetic gypsum derived from different power plants and from different configurations of pollution-control devices. In the first test, the reported total mercury that was lost between the incoming gypsum and the final product was 5 percent. In the second test, the

311 Coal Ash Facts, http://www.coalashfacts.org/.

312 Charles E. Miller et al., "Mercury Capture and Fate Using Wet FGD at Coal-Fired Power Plants," cited above.

313 "Soaring Use of Coal Waste in Homes Risks Consumer Headache," Public Employees for Environmental Responsibility (PEER), 2010, http://www.peer.org/news/news_id.php?row_id=1327.

314 U.S. Geological Survey, Mineral Commodity Summaries, January 2012 page 71

315 "Technical Background Report to the Global Atmospheric Mercury Assessment," AMAP and UNEP, cited above.

reported total loss was 8 percent. In the third test, the reported total loss was 46 percent. The total losses in the fourth test were not reported but appear to have been small. And in the fifth test, the total reported loss was 51 percent.[316]

These test results suggest that there may be significant releases of mercury into the environment and the workplace during the manufacture of wallboard from waste-derived synthetic gypsum. There may also be mercury releases from synthetic gypsum before the material even reaches the wallboard plant. The growing use of waste-derived synthetic gypsum may negate the effectiveness of FGDs in removing mercury from flue gas because much of the mercury originally removed by FGDs may be subsequently reemitted into the environment before or during the manufacture of the wallboard.

The above-described tests and the report on them were done for the U.S. EPA by scientists at a leading company that manufactures wallboard with synthetic gypsum. The report indicated that the mercury content of the outgoing wallboard in the tests ranged from a high of 0.95 ppm to a low of 0.02 ppm.[317] Little independent data, however, appears to be available on the mercury content of wallboard made from synthetic gypsum. One study by the U.S. EPA did report that the mercury content of two tested samples of wallboard manufactured in the U.S. were 2.08 ppm and 0.0668 ppm. The same study found that the mercury content of two tested samples of wallboard manufactured in China were 0.562 ppm and 0.19 ppm.[318] Much more independent data is needed on the mercury content of waste-derived synthetic gypsum wallboards.

There appear to be no available studies on the mercury exposure of workers who install these wallboards. One published study by industry scientists and consultants, however, purports to show that mercury in the indoor air of rooms with wallboards made from synthetic gypsum is not a cause for concern. It is not clear from the study, however, how its methodology and results can be used to justify this conclusion. The report on the study does provide some interesting data. It measured mercury fluxes in small chambers containing samples of natural gypsum wallboard and chambers containing samples of synthetic gypsum wallboard. It found fluxes of 0.92 ± 0.11 nanograms per square meter (ng/m2) per day for natural gypsum wallboard and found fluxes of 5.9 ± 2.4 ng/m2 per day for synthetic gypsum wallboard.[319] That is, the measured mercury fluxes associated with the synthetic gypsum wallboard were six times higher than those associated with the natural gypsum wallboard. This suggests a possible cause for concern. Independent research on mercury releases from synthetic gypsum would be most useful.

Fly ash that has been captured in the fabric filters and electrostatic precipitators of coal-fired power plants is also put to use. According to an industry trade association, 70 million tons of fly ash are produced in the United States each year. Nearly 45 percent of this fly ash is subsequently recycled for some use, and the power plant operators are doing what they can to increase this percentage. Much of the fly ash is mixed in various portions with cement to make concrete. Industry sources claim that the mercury is tightly bound to the fly ash and very little mercury is released from the finished concrete or during concrete mixing and drying. There does not,

316 Charles E. Miller et al., "Mercury Capture and Fate Using Wet FGD at Coal-Fired Power Plants," cited above.

317 Jessica Sanderson, "Fate of Mercury in Synthetic Gypsum Used for Wallboard Production," USG Corporation, 2008, http://www.netl.doe.gov/technologies/coalpower/ewr/coal_utilization_byproducts/pdf/42080FinalRpt20080624.pdf.

318 "Drywall Sampling Analysis," U.S. EPA, 2009, linked to http://www.pharosproject.net/index/blog/mode/detail/record/40.

319 Scott S. Shock et al., "Evaluation of Potential for Mercury Volatilization from Natural and FGD Gypsum Products Using Flux-Chamber Tests," *Environmental Science & Technology*, March 2009, http://pubs.acs.org/doi/abs/10.1021/es802872n#afn3.

however, appear to be sufficient independent data available to support this claim. Nor does there appear to be any data available that estimates total global mercury emissions associated with the manufacture and use of building materials derived from fly ash. Furthermore, as plant operators around the world introduce technological innovations to increase the mercury-capture efficiencies of their air pollution control devices, the total mercury content of fly ash and other APCD residues will grow. Work is needed to track the ultimate environmental fate of mercury contained in fly ash and in other residues captured by APCDs.

Power plants send some of the fly ash captured in electrostatic precipitators and fabric filters to cement kilns, where the fly ash is mixed with other raw materials and the mixture is then heated to as high as 1450°C. At these high temperatures, virtually all of the mercury in the fly ash—mercury that had originally been removed from power plant flue gas by electrostatic precipitators and fabric filters—is vaporized and again released, this time into cement kiln flue gas.[320]

Power plant operators seek uses for their coal-combustion products in order to reduce their waste disposal costs. As the world moves toward stricter regulatory controls on mercury emissions from coal-fired power plants, global supplies of mercury-rich fly ash and other APCD residues will grow rapidly as will incentives to expand existing markets for APCD residues and to find new ones.

The practice of reusing APCD residues, however, appears to remobilize much of the mercury that APCDs at coal power plants had previously captured. A global mercury treaty should give careful consideration to the prevention of practices that result in mercury reemissions that contribute to global atmospheric mercury or that pollute the indoor air of homes and workplaces.

320 "Cementing a Toxic Legacy?" Earthjustice Environmental Integrity Project, 2008, http://www.earthjustice.org/sites/default/files/library/reports/ej_eip_kilns_web.pdf.

LOCAL AND GLOBAL ASPECTS OF MERCURY POLLUTION

Mercury emissions from coal-fired power plants often attract more public and political attention and study than do most other mercury pollution sources. One reason is that the air emissions from poorly controlled coal-fired power plants include not only gaseous elemental mercury emissions but also large quantities of particle-bound mercury and oxidized mercury (such as mercury chloride and mercury oxide). Though most of the gaseous elemental mercury emissions remain in the atmosphere for a long period of time, the particle-bound mercury and the oxidized mercury tend to have much shorter residency in the atmosphere and tend to fall to earth downwind of these power plants. For example, research in the U.S. state of Ohio found that more than 70 percent of the mercury associated with precipitation (wet deposition) came from local coal-fired power plants.[321] Because much of a power plant's particle-bound mercury and oxidized mercury emissions falls to earth relatively near the plant, this tends to increase the amount of methylmercury in lakes and rivers downwind of power plants and in the fish caught in them. When regulators and the public become aware of this connection between poorly controlled coal-fired power plants and heightened levels of methylmercury contamination in fish from downwind lakes and rivers, public and political pressure for monitoring and better controlling power plant emissions often intensifies.

On the other hand, any anthropogenic mercury source that releases mainly gaseous elemental mercury emissions will tend to have a much smaller localized environmental impact. Gaseous elemental mercury emissions tend to remain in the atmosphere for six months to two years and tend to be spread by winds all across the earth. This mercury eventually also falls to earth, but with little, if any, obvious connection between the pollution source and the water body where the polluted fish are found. As a result, there is often less public and political understanding of the relationship between sources of gaseous elemental mercury emissions and their eventual environmental impact. For those human activities that mainly release mercury into the atmosphere in the form of gaseous elemental mercury, the impact tends to be globally diffuse rather than local or regional. Therefore, a global approach is needed to fully understand the impact of such emissions, and only a global approach can effectively protect human health and the environment from them.

Another strategy that coal power plants can use to reduce mercury emissions is coal cleaning and other forms of coal preprocessing. Plants widely use coal cleaning on bituminous coal to remove mining residues and to reduce ash and sulfur. Current common bituminous coal-cleaning practices are estimated to reduce mercury emissions from power plants by approximately 37 percent.[322] More advanced coal cleaning and coal-treatment processes that can achieve higher mercury-removal efficiencies have also been discussed and promoted. One example that has

321 Emily M.White, Gerald J. Keeler, and Matthew S. Landis, "Spatial Variability of Mercury Wet Deposition in Eastern Ohio: Summertime Meteorological Case Study Analysis of Local Source Influences," *Environmental Science & Technology* 43, no. 13, 2009, p. 4,946-53, doi:10.1021/es803214h, http://dx.doi.org/10.1021/es803214h.

322 B. Tooleoneil et al., "Mercury Concentration in Coal—Unraveling the Puzzle," *Fuel* 78, no. 1, 1999, p. 47-54, doi:10.1016/S0016-2361(98)00112-4, http://dx.doi.org/10.1016/S0016-2361(98)00112-4.

been cited is K-fuel technology. This is a proprietary technology that uses heat and pressure to physically and chemically transform low-rank fuels into low-moisture, high British Thermal Unit (BTU) solid fuels. The process removes ash and mercury from the coal and thus has the potential to produce fuels with low mercury content and with increased heating value.[323]

In most cases, decisions by power plant or boiler operators to use cleaned or treated coal are driven by economic considerations such as the need to increase the fuel efficiency of available coal or the need to meet pollution-control standards without large new investments in plant efficiency or APCDs. Expert opinion, however, appears to be divided on the extent to which advanced coal cleaning and coal-treatment processes are economically competitive with other potential mercury-control technologies.[324] The mercury treaty, however, might influence such economic calculations. It might encourage additional research and development in this area, and it may even create incentives for operators to both improve their plant efficiencies and APCDs and to also use coal that has been subjected to advanced cleaning or treatment processes.

To review, many different techniques can be used to reduce mercury emissions from coal-fired power plants and industrial boilers. These include the following:

- Measures to increase power plant and boiler efficiency.
- Installing and/or upgrading air pollution control devices.
- Using various techniques to more completely convert gaseous elemental mercury in flue gases into oxidized mercury and/or particle-bound mercury.
- Cleaning, blending, or otherwise preprocessing coal.
- Substitution, that is, deciding to replace coal-fired power plants with alternative energy sources that generate less mercury pollution or that generate no mercury pollution.

The mercury treaty can promote research into improving the efficiency and reducing the price of mercury-reduction techniques and technologies such as those listed above. Additionally, it can promote research on approaches that can expand the available choices. In the end, however, which of these techniques, if any, that an operator decides to employ in order to reduce mercury pollution will depend on many factors. One important factor will be the characteristics and prices of locally available coal supplies, because the performance of different mercury-control

323 James Kilgroe et al., "Fundamental Science and Engineering of Mercury Control in Coal-Fired Power Plants," cited above.

324 Charles E. Miller et al., "Mercury Capture and Fate Using Wet FGD at Coal-Fired Power Plants," cited above.

techniques may vary depending on the characteristics of the coal being burned. Other important factors include the local cost and availability of technologies and techniques to enhance facility efficiency or to effectively remove mercury from flue gasses; the cost of appropriately managing any resultant wastes, especially mercury waste releases or transfers; and the availability of the local know-how necessary to make good technology selections and to then effectively deploy them.

In most cases, however, even if effective mercury-control techniques and technologies are available, power plant operators will not invest in them in the absence of a regulatory driver, an economic driver, or both. This is because power plant operators have a strong incentive to generate electricity at the lowest possible cost. However, the mercury treaty, with legally binding measures such as BAT/BEP, can minimize the economic advantage that the biggest polluters now get and can help level the playing field for everyone.

However, operators will spend their own money to reduce mercury emissions if driven to do so by government policy and government regulations, especially if they understand that not complying will cost them even more than their compliance costs. Additionally, even in the absence of a specific binding requirement, operators will agree to employ effective mercury-reduction techniques if they are given appropriate incentives. Such incentives can include financial or technical assistance. Or they can include enhanced access to technologies and techniques that improve plant-operating efficiencies and thereby reduce the cost of producing a unit of energy output. The challenge to Parties to the mercury treaty at future COPs will be to reach agreements on a package of measures that includes both well-designed and enforceable, legally binding regulations and also sufficient financial and technical incentives that, when put together, will be able to drive significant global reductions in power plant mercury pollution.

The current negotiated package goes some way to reconcile the competing goals of positively contributing to reductions in global mercury emissions while, at the same time, maintaining or even enhancing national economic development and poverty-reduction objectives but there is still a great deal of work to be done in terms of guidance on issues such as BAT/BEP. Achieving this will take hard work and creative efforts by negotiators who recognize both the serious harms to human health and the environment caused by mercury pollution but also the urgent need of many developing countries to enhance their access to reliable electricity by expanding national energy-generation capacity.

What does the mercury treaty say about coal-fired power plants?

In order to reach meaningful agreements on controlling mercury releases from coal-fired power plants, it is necessary to phase in binding and enforceable control measures over a period of time. The measures of the mercury treaty are formulated in terms that are similar to the provisions on best available techniques (BAT) contained in the Stockholm Convention on Persistent Organic Pollutants. These measures could, under agreed-upon conditions, require governments that are party to the treaty to mandate and/or promote the use of BAT at coal-fired power plants in their countries. The mercury treaty prioritizes and obligates developed countries to provide technical and financial assistance to developing countries and countries with economies in transition in order to ensure that parties can implement the treaty's provisions without undermining their national economic development and poverty-reduction objectives. The Global Environment Facility (GEF) will also make available a financial trust to assist with the implementation of specific measures. The COP will provide further guidance on strategies, policies, priorities, eligibility, and an indicative list of categories of activities that could receive support from the GEF.

As with the Stockholm Convention, a fully elaborated BAT/BEP definition and guidelines are not written into the mercury treaty text itself. Rather, the mercury treaty defines BAT/BEP in conceptual terms and instructs the Conference of Parties (COP) to establish a BAT/BEP Experts Group to prepare draft BAT/BEP guidelines for adoption by the COP and to also periodically review and update the guidelines. These evolving BAT/BEP guidelines are likely to include revisions and updates that address the schedules and conditions under which mercury treaty BAT/BEP provisions become legally binding. The mercury treaty requires BAT/BEP to apply to all new coal burning facilities no later than five years after the treaty enters into force for that Party.

On a parallel track, the COP will also undertake periodic reviews of the practical availability of technical and financial assistance that support the implementation of the BAT/BEP guidelines. The outcomes of such reviews might be closely linked to decisions on the schedules and conditions under which the BAT/BEP provisions become legally binding. This two-track approach may enhance implementation of the mercury treaty and impose meaningful controls on coal-fired power plants without undermining national economic development and poverty-reduction objectives.

As in the Stockholm Convention, BAT/BEP guidelines might additionally include provisions that encourage operators wishing to build a new power plant or to substantially modify an existing one to give consideration to alternative energy technologies that release less or no mercury into the environment. If such provisions are written into the guidelines, then technical or financial support that might become available to assist in the implementation of mercury treaty BAT provisions could be used to instead deploy alternative-energy technologies.

10.2 OTHER FOSSIL FUEL COMBUSTION

Commonly reported estimates of mercury emissions from fossil fuel combustion sources other than coal-fired power plants appear to be less complete and less accurate than are estimates of emissions from coal-fired power plants. Many governments in Western Europe, North America, and elsewhere have required extensive monitoring of the stack-gas emissions of coal-fired power plants in their countries, and this monitoring has often included measurements of mercury emissions. As a result, much data has been collected on mercury emissions from coal-fired power plants in many countries. This data has made possible the development of emissions factors that have been used to roughly estimate power plant mercury emissions even in countries where power plant stack-gas monitoring has been less common. On the other hand, estimated mercury emissions from fossil fuel combustion sources other than coal-fired power plants appear to be based on less data and less-extensive study.

Residential Heating

Mercury emissions from coal combustion for residential and commercial heating, cooking, and other similar sources have been estimated to be approximately 20 percent of total global anthropogenic mercury emissions.[325] The use of coal for residential heating also releases greenhouse gasses into the environment. It additionally releases other noxious pollutants that contribute to serious local air pollution and associated respiratory and other diseases. Therefore, measures to promote and enable the replacement of coal-burning furnaces and stoves with less-polluting residential-heating alternatives will not only reduce total global mercury pollution but can also help reduce global greenhouse gas emissions as well as harmful local air pollution.

Petroleum Products

Refining and burning petroleum and its products also contributes to global mercury pollution. According to an industry technology provider, mercury is a common component of petroleum, and the processing of petroleum is often ac-

325 AMAP/UNEP, 2013. Technical Background Report for the Global Mercury Assessment 2013. Arctic Monitoring and Assessment Programme, Oslo, Norway/UNEP Chemicals Branch, Geneva, Switzerland. vi + 263 pp. page20.

companied by generation of waste streams that contain some mercury. Mercury-removal systems are common in the industry, and the main incentive for their use is to protect the plant's equipment and catalysts. Plants without mercury-removal systems generate mercury-contaminated sludge, sediments, and other waste streams. In some locations where the mercury concentration in process feeds is high, treatment systems for properly managing mercury wastes may not be readily available or affordable.[326]

The UNEP/AMAP 2013 report[327] indicates that assessment of a wide range of crude oil samples by country of origin reveals great variation in mercury content. UNEP/AMAP cite Wilhelm et al 2007[328] who conclude that the range of variation or mercury in crude oil is 0.1 to 20,000 ppb and that oil from Thailand and Vietnam are exceptionally high (by comparison, the " UNEP/AMAP Technical Background Report 2008" indicates that the concentrations of mercury in coal tends to be in the range of 0.01 ppm and 1.5 ppm.) UNEP/AMAP 2013 also estimate that 25 percent of the mercury in crude oil is released as emissions to air during the refining process (this is separate to emissions released during combustion of fossil fuels for energy or heating.) Their current estimate is that oil refining (not combustion) contributed 16 metric tons of mercury via air emissions representing 1 percent of total global air emissions of mercury.

The "UNEP/AMAP Technical Background Report 2008" suggests that mercury emissions associated with the combustion of petroleum products tend to be between one and two orders of magnitude lower than mercury emissions from coal combustion, but this conclusion is admittedly based on limited data. More work is needed to develop better estimates of mercury atmospheric emissions and other releases from plants that process petroleum and its products, and work also is needed to estimate mercury emissions from facilities and vehicles that burn petroleum products.

Petroleum Products from Shale and Oil Sands

Producing petroleum products from shale is expensive at current oil prices and at present only a few deposits of oil shale are being used to produce petroleum prod-

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326 "Generation and Disposal of Petroleum Processing Waste That Contains Mercury," Mercury Technology Services, http://hgtech.com/Publications/waste.html.

327 AMAP/UNEP, 2013. Technical Background Report for the Global Mercury Assessment 2013. Arctic Monitoring and Assessment Programme, Oslo, Norway/UNEP Chemicals Branch, Geneva, Switzerland. vi + 263 pp. page 176.

328 Wilhelm, S., Liang, L., Cussen, D., and Kirchgessner, D., 2007. "Mercury in crude oil processed in the United States (2004)". Environmental Science and Technology, Vol. 41, No. 13, pp 4509-4514. http://pubs.acs.org/doi/pdf/10.1021/es062742j

ucts. Oil production from shale currently takes place in Brazil, China, Estonia, Germany and Israel.[329] No data appears to be available on mercury releases from the production of oil from shale. Nonetheless, processing shale to produce oil can be a source of mercury releases to the environment. Large reserves of oil shale exist and as oil prices rise, these reserves may increasingly become utilized for oil production.

A 1983 study of Green River Formation shale suggests that producing oil from shale can release large quantities of mercury to the environment.[330] The study estimates that between 8 and 16 kilograms of shale must be processed to produce each liter of product oil. Trace quantities of mercury are present in the shale in concentrations that are typical for sedimentary materials. During processing, the shale is heated to 5000C and there is a potential for the mobilization of almost all its mercury content due to the volatility of mercury and its compounds. The study estimates that a facility that processes sufficient Green River Formation shale to produce 8 million liters of oil per day would generate approximately 8 kilograms of mercury air emissions per day.

The production of petroleum products from oil sands (also called tar sands) can be another source of mercury pollution. Little data is available on mercury releases from this source, but a recent study has found evidence that the Canadian oil sands industry has released significant quantities of mercury to the Athabasca River and its watershed.[331] More and better data should be made available on mercury releases from both the oils sands industry and the shale oil industry.

Natural Gas

There is also little information available on mercury releases associated with the combustion of natural gas. As indicated in an earlier section of this booklet, mercury is routinely removed from natural gas that is liquefied because even in quite low concentrations, mercury can corrode the downstream equipment used during the process. However, outside of the European Union, little data is available on the environmental fate of this removed mercury.

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329 2007 "Survey of Energy Resources," World Energy Council, http://www.worldenergy.org/documents/ser2007_final_online_version_1.pdf

330 "Mercury Emissions from a Modified In-Situ Oil Shale Retort," Alfred T. Hodgson, et al, Atmospheric Environment, 1984

331 "Oil sands development contributes elements toxic at low concentrations to the Athabasca River and its tributaries." Erin N. Kelly and David W. Schindler, et al, Proceedings of the National Academy of Sciences of the United States of America, July 2010, http://www.pnas.org/content/107/37/16178.full?sid=800be74f-98bb-4117-a945-bb9ec73936b0

Also, some countries and regions have such high concentrations of mercury in their natural gas that operators must remove mercury from the gas before distributing it. This is reportedly the case in some countries bordering the North Sea and in Algeria and Croatia. Based on data provided in UNEP's "Summary of Supply, Trade and Demand Information on Mercury" report, it appears that natural gas with similarly high levels of mercury may be found in some South American, Far Eastern, and Middle Eastern countries and in South Africa, Sumatra, and possibly other countries as well. Presumably, if mercury is not removed from such gas and if the gas is distributed and used, this will result in significant mercury emissions. Flaring of natural gas during production can also release significant amounts of mercury. According to estimates by the Arctic Council in their report "Assessment of Mercury Releases from the Russian Federation"[332] gas production in Western Siberia in 2001 was about 19 billion m^3. By using the average content of mercury in casinghead gas, the flared gas would contain 65 kg of mercury. As with oil products, there is clearly a need for more data and more work in this area by UNEP and others.

What does the mercury treaty say about mercury and other fossil fuel combustion?

During negotiations for the mercury treaty oil and gas industries were excluded from the requirements of Article 8 Emissions (Air).

10.3 CEMENT PRODUCTION

According to UNEP's "Global Mercury Assessment 2013," cement kilns annually release an estimated 173 metric tons of mercury into the atmosphere (although an upper limit estimation places emissions as high as 646 metric tons). This former value is approximately 9 percent of UNEP's estimated total of global anthropogenic mercury emissions to the atmosphere.

Much of the mercury released from cement kilns occurs naturally in the raw materials used to manufacture cement. These include sources of calcium, the element of highest concentration in cement. Raw materials from which calcium is derived include limestone, chalk, sea shells, and other naturally occurring forms of calcium carbonate. Another raw material source category is ores and minerals that contain elements such as silicon, aluminum, or iron. These include sand, shale, clay and

332 ACAP. 2005. *Assessment of Mercury Releases from the Russian Federation*. Arctic Council Action Plan to Eliminate Pollution of the Arctic (ACAP), Russian Federal Service for Environmental, Technological and Atomic Supervision & Danish Environmental Protection Agency. Danish EPA, Copenhagen. page 177

iron ore.[333] These raw materials can all contain some quantity of naturally occurring mercury. They are ground and mixed together before going into the kiln.

Many cement kiln operators additionally mix into these naturally occurring raw materials quantities of the fly ash from power plant air pollution devices. As noted above, this fly ash contains mercury that was previously captured by fabric filters or electrostatic precipitators at the coal-fired power plants where the fly ash originated. In 2005, 39 cement plant operators in the United States reportedly mixed a total of 2.7 million metric tons of fly ash into the raw materials going into their cement kilns.[334]

In addition to the raw materials, cement kilns also use large quantities of fuels to heat the raw materials to a high temperature. Fuels used in cement kilns include coal, petroleum coke, heavy fuel oil, natural gas, landfill off-gas and oil refinery flare gas. In addition to these primary fuels, combustible waste materials are also often fed to kilns, including used tires and hazardous wastes.[335] These fuels can also contain significant quantities of mercury. Landfill off-gas may be especially problematic because it may contain mercury that had originally entered the landfill through end-of-life mercury-containing products. The UNEP 2013 report updates its estimates in an attempt to account for emissions from some cement kiln fuels, "*including alternative fuels (such as old tyres and other wastes) and from raw materials. Increasing amounts of waste are being co-incinerated in the cement industry both as fuel but also, in some plants, as a means of disposing of hazardous wastes, some of which may contain mercury.*"[336]

The mixed raw materials, often including fly ash, are fed into the kiln and heated to temperatures as high as 1,450oC. At these temperatures, the elements in the raw materials melt and react with one another to produce silicates and other compounds. The material produced in the kiln is called clinker, and it contains two-thirds or more calcium silicates by weight. The clinker is then ground into a fine powder, which is the main constituent of cement.[337]

At the high temperatures reached in the cement kiln, the mercury that is present in the raw materials, the fuel and the fly ash vaporizes. Air pollution control devices may capture some in the cement kiln stack, but much of this mercury is released into the atmosphere.

333 "Locating and Estimating Air Emissions from Sources of Mercury and Mercury Compounds," Portland Cement Manufacturing, U.S. EPA, 1997, http://www.epa.gov/ttnchie1/le/mercury.pdf.

334 "Cementing a Toxic Legacy?" Earthjustice Environmental Integrity Project, cited above.

335 Wikipedia entry on cement kiln, http://en.wikipedia.org/wiki/Cement_kiln.

336 UNEP, 2013. Global Mercury Assessment 2013, Sources, Emissions, Releases and Environmental Transport. UNEP Chemicals Branch, Geneva, Switzerland. page 10

337 Wikipedia entry on cement kiln cited above.

A LIST OF CEMENT KILN POLLUTANTS

Cement kilns release not only mercury and its compounds into the atmosphere but also many other pollutants. The main pollutant released from cement kilns is the greenhouse gas carbon dioxide, which is produced by both fuel combustion and reactions taking place in the raw materials.

Other cement kiln emissions include the following:

- **Lead and its compounds.**
- **Chromium and its compounds.**
- **Manganese and its compounds.**
- **Zinc and its compounds.**
- **Nickel and its compounds.**
- **Benzene, ethylbenzene, toluene, xylene, ethylene glycol, and methyl isobutyl ketone.**
- **Polycyclic aromatic hydrocarbons.**
- **Dioxins, furans, and PCBs.**
- **Tetrachloroethylene and dichloromethane.**
- **Particulate-matter emissions.**
- **Nitrogen oxides.**
- **Sulfur dioxide and sulfuric acid.**
- **Carbon monoxide.**
- **Organically bound carbon.**
- **Gaseous inorganic chlorine compounds such as hydrogen chloride.**
- **Gaseous inorganic fluorine compounds[338,339]**

In August 2010, the U.S. EPA finalized new regulations that will control mercury emissions from all U.S. cement kilns. According to agency claims, when these new rules are fully implemented in 2013, mercury emissions from U.S. cement kilns will be reduced by 7.5 metric tons (16,600 pounds). This would be a reduction of 92 percent from present levels.[340]

The regulation establishes mercury emission limit values for cement kilns. Under normal operating conditions, new cement kilns will be limited to 21 pounds (9.5

338 Ibid.

339 "Taking Stock: 2003 North American Pollutant Releases and Transfers," Commission for Environmental Cooperation, July 2006, http://www.cec.org/Storage/60/5254_TS03_Overview_en.pdf.

340 "EPA Sets First National Limits to Reduce Mercury and Other Toxic Emissions from Cement Plants," U.S. EPA press release, August 9, 2010, http://yosemite.epa.gov/opa/admpress.nsf/e77fdd4f5afd88a3852576b3005a604f/ef62ba1cb3c8079b8525777a005af9a5!OpenDocument.

kg) of mercury emission per million metric tons clinker produced. Existing mills will be limited to 55 pounds (25 kg) of mercury emissions per million metric tons of clinker produced. Operators will be required to continuously monitor their mercury emissions to ensure they comply with the emission limit values. The new rules will relax existing U.S. restrictions on the use of fly ash as a feedstock in cement kilns but only after the rules on mercury emission limit values are being enforced (and presumably met). Besides controlling mercury emissions, the new rules will also control cement kiln emissions of total hydrocarbons, particulate matter, acid gases, sulfur dioxide (SO2), and nitrogen oxides (NOx).[341] Continuous monitoring of mercury emissions from cement kilns is also a legally binding requirement in at least two other countries: Germany and Austria.[342]

The U.S. EPA estimates that compliance with its new cement kiln rules will cost the industry between U.S.D 926 million and 950 million annually starting in 2013, when the rules take effect. The EPA additionally estimates that the rules will yield health and environmental benefits valued at between U.S.D 6.7 billion and 18 billion annually.[343]

Based on the U.S. EPA's new cement kiln rules, three observations can be made:

- Substantially reducing mercury emissions from cement kilns is technically feasible.
- There are significant costs associated with reducing mercury emissions from cement kilns.
- The health and environmental benefits achieved by substantially reducing mercury emissions from cement kilns have a value that can be between seven and 20 times greater than the costs of reducing the emissions.

What does the mercury treaty say about mercury and cement kilns?

The mercury treaty promotes and requires substantial reductions in mercury emissions from cement kilns, and the progressive phase-in of strict mercury emission limits and/or BAT/BEP requirements. It remains to be seen if these

341 "National Emission Standards for Hazardous Air Pollutants from the Portland Cement Manufacturing Industry and Standards of Performance for Portland Cement Plants, U.S. EPA Final Rule, August 2010, http://www.epa.gov/ttn/oarpg/t1/fr_notices/portland_cement_fr_080910.pdf.

342 "Reference Document on Best Available Techniques in the Cement, Lime and Magnesium Oxide Manufacturing Industries," European Commission, May 2010, ftp://ftp.jrc.es/pub/eippcb/doc/clm_bref_0510.pdf.

343 "EPA Sets First National Limits to Reduce Mercury and Other Toxic Emissions from Cement Plants," U.S. EPA press release, cited above.

provisions are closely linked to the availability of adequate technical and financial assistance to developing countries and countries with economies in transition. There are suggestions in the current treaty text that this is likely to be the case but will be determined by further guidance from the COP when negotiating details of the BAT/BEP requirements and its alternatives within the treaty.

10.4 METALS MINING AND REFINING

Mercury and mercury compounds are often present, sometimes in relatively high concentrations, in the ores from which metals are produced. According to UNEP's reported emission estimates, industrial gold production (not counting artisanal and small-scale gold mining) accounts for 5 percent to 6 percent of global mercury emissions to air from human activities, while mining and smelting metals other than gold account for approximately 12 percent of the total. According to the report, mercury is not intentionally used in mining or in producing metals other than gold, nor is the intentional use of mercury in industrial gold mining the norm. Therefore, intentional mercury use contributes only a small part to the mercury emissions from industrial mining and refining operations.[344] This suggests that approximately 15 percent of the total of all anthropogenic mercury emissions comes from unintentional mercury releases associated with industrial-scale metals mining and refining operations and facilities.

UNEP's "Global Mercury Assessment 2013" report indicates that one of the mechanisms contributing to mercury releases from mining is the weathering of newly exposed mercury-containing rocks. The report suggests, however, that the main source of mercury emissions from industrial mining and refining is the processing of ores that have high mercury content, especially when these metal ores are processed using high-temperature smelting or thermal roasting. One facility for roasting gold ore in Western Australia – The Gidji Roaster- is one of the largest point sources of mercury releases in the world with over 5 metric tons of mercury emitted to air annually according to the Australian version of the PRTR, the National Pollutant Inventory. In 2008 the Gidji Roaster, owned by Kalgoorlie Consolidated Gold Mines Pty Ltd (KCGM) released up to 7000 kg of mercury to air.[345]The UNEP report further suggests that air pollution control devices on smelters can prevent mercury emissions in the same ways that APCDs prevent emissions from coal-fired power plants.[346]

344 "Global Atmospheric Mercury Assessment," UNEP, cited above.

345 Western Australian Parliamentary Hansard (2010) Question On Notice No. 2716 asked in the Legislative Council on 7 September 2010

346 "Global Atmospheric Mercury Assessment," UNEP, cited above.

Silver, gold, copper, lead, zinc, and mercury all tend to occur in the same or similar geological formations and tend to be intermixed.[347] The amount of mercury in ore varies greatly. According to a U.S. EPA source, gold ores in the U.S. typically contain between 0.1 ppm and 1,000 ppm mercury, zinc ores typically contain between 0.1 ppm and 10 ppm mercury, and copper ores typically contain between 0.01 ppm and 1 ppm mercury.[348] A recent study estimated that primary zinc-production facilities in China released between 81 and 104 metric tons of mercury emissions into the atmosphere between 2002 and 2006.[349] Another recent study found that modern-scale production facilities equipped with pollution-control devices such as an acid plant and a mercury-reclaiming tower can significantly reduce mercury emissions from zinc smelters in China.[350]

Iron ore typically contains less mercury than most other metal ores. In the U.S. state of Minnesota, where iron ore is mined and processed, for example, tests of the mercury content of the ore have found concentrations as low as 0.001 ppm and as high as 0.9 ppm, although it appears most of the tested ores had mercury concentrations less than 0.32 ppm. Iron ore pellets are heated for processing to reduce the impurities in the ore before it is shipped to primary iron- and steel-making facilities. Minnesota iron ore produces an estimated 300 kg to 350 kg of mercury emission per year. [351]

The main source of mercury emissions in primary iron and steel production, however, is not the ore but metallurgical coke. The coke is made from coal and iron producers use it to reduce the oxidized iron present in the ore in order to convert

347 W. Charles Kerfoot et al., "Local, Regional, and Global Implications of Elemental Mercury in Metal (Copper, Silver, Gold, and Zinc) Ores," Journal of Great Lakes Research, 2004, http://www.bio.mtu.edu/faculty/kerfoot/jglr_hg_30_sup1_162-184.pdf.

348 Alexis Cain, "Mercury Releases from Industrial Ore Processing," U.S. EPA, December 6, 2005, http://www.epa.gov/bns/reports/stakesdec2005/mercury/Cain2.pdf.

349 Guanghui Li et al., "Mercury Emission to Atmosphere from Primary Zn Production in China," *Science of the Total Environment*, September 2010, http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V78-50KVG3K-3&_user=10&_coverDate=09%2F15%2F2010&_rdoc=1&_fmt=high&_orig=search&_sort=d&_docanchor=&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=685c0374da431ad9c9b8ebf3acf76710.

350 S.X. Wang et al., "Estimating Mercury Emissions from a Zinc Smelter in Relation to China's Mercury Control Policies," *Environmental Pollution*, July 2010, http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VB5-50SSKM6-1&_user=10&_coverDate=08%2F15%2F2010&_rdoc=1&_fmt=high&_orig=search&_sort=d&_docanchor=&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=8622d6c12c9ef4a5b7ddc9995d345e9f.

351 Michael E. Berndt, "Mercury and Mining in Minnesota," Minnesota Department of Natural Resources, 2003, http://files.dnr.state.mn.us/lands_minerals/mercuryandmining.pdf.

it into metallic iron. Most mercury emissions from primary iron and steel production appear to result from the mercury content of the coal and are released when the coke is produced or used. Secondary steel production, on the other hand, does not use iron ore or coke. Instead, it produces steel from steel scraps such as old automobiles and appliances. Nonetheless, there are considerable mercury emissions from secondary steel production that come mainly from mercury-containing switches or other electrical devices that are often present in the scrapped steel.

METAL ORE MINING IS A HUGE SOURCE OF MERCURY POLLUTION

The UNEP "Global Atmospheric Mercury Assessment 2008" report suggests that most of the global mercury air emissions from metal mining and refining activities derive from smelters and other high-temperature ore refining processes and not from mining itself. It appears, however, that mercury air emissions and other mercury pollution that result directly from metal ore mining may have been underestimated.

This conclusion follows a review of 2008 data found in the U.S. Toxics Release Inventory (TRI),[352] which covers all reported U.S. releases and disposal of mercury and mercury compounds from 46 *metal ore mining* facilities and 143 smelters and other *primary metals refining* facilities.

The data on *metal ore mining* comes from all U.S. establishments that are primarily engaged in developing mine sites or mining metallic minerals as well as establishments primarily engaged in ore dressing and beneficiating (i.e., preparing) operations, which involve crushing, grinding, washing, drying, sintering, concentrating, calcining and leaching the ore.

The data on *primary metals refining* comes from all U.S. establishments that smelt and/or refine ferrous and nonferrous metals from ore, pig iron, or scrap using electrometallurgical and other metallurgical process techniques.[353]

When we consider the reported air emissions of mercury and mercury compounds from the facilities in the two categories listed (including the total of both *point source air emissions* and *fugitive air emissions*), smelting and refining operations have slightly higher reported air emissions than do metal ore mining facilities. The reported 2008 mercury air emissions from U.S. metal smelting and refining operations is 3.86 metric tons (8,515 pounds); the reported 2008 mercury emissions from U.S. metal ore mining operations is 2.13 metric tons (4,701 pounds).

However, when we compare all the waste releases and waste transfers of mercury and mercury compounds from the facilities in the two categories listed above the picture changes. In 2008, the total of reported mercury releases and transfers from all U.S. metals smelters and refining facilities was 10.06 metric tons (22,174 pounds). The 2008 total of reported mercury releases and transfers from all U.S. metal ore mining facilities, on the other hand, was 2,486.24 metric tons (5,481,215 pounds). In other words, *the total of mercury releases and transfers from all U.S. metal ore mining operations was almost 250 times greater than the total of 2008 mercury wastes and transfers from all U.S. metal smelters and refining facilities.*

352 See http://www.epa.gov/triexplorer/

353 Data is for NAICS codes 2122 and 331. NAICS is the North American Industry Classification System , U.S. Census Bureau. Definitions of 200 NAICS codes can be found at http://www.census.gov/eos/www/naics/.

This is not to suggest that metals smelters and refiners are not a significant source of mercury pollution. It is only to suggest that metal ore mining is a large and often relatively ignored source of mercury releases to the environment.

Of the almost 2,500 metric tons of mercury and mercury compounds released into the environment in 2008 from U.S. mining operations, almost all of it stayed on-site and was released to land. None (0 pounds) was put into certified hazardous waste landfills and approximately 10 percent was put into landfills that are not certified for hazardous waste. The majority, approximately 90 percent of the mercury and mercury compounds—a reported 2,205.22 metric tons (4,861,684 pounds)—was just dumped. (The technical description of this waste disposal category is "on-site land disposal other than landfills including activities such as placement in waste piles and spills or leaks.")[354]

When we consider that metal ore mining in the United States (where good data is easily available) makes up only a small fraction of total global metal ore mining and that in the United States alone, the amount of mercury and mercury compounds in wastes dumped at metal ore mining sites in one year (2008) was more than 2,200 metric tons, we see that the global total of mercury and mercury compounds contained in all dumped mining wastes at all past and present metal ore mining operations must be extremely large. These dumped wastes are continuously subject to weathering activities and other natural processes that certainly result in high but unrecorded air emissions, water discharges, and other mercury releases from mining waste dumps.

What does the mercury treaty say about mercury and metals mining and refining?

The mercury treaty recognizes these issues and includes provisions under Articles 8 and 9 to address mercury atmospheric emissions and other environmental releases (i.e. to land and water) from both nonferrous and ferrous metals mining and refining operations.

354 See definition of "Other On-site Land Disposal" at http://yosemite1.epa.gov/oiaa/explorers_fe.nsf/Doc1/Other+Disposal?OpenDocument.

11. MERCURY WASTES AND CONTAMINATED SITES

Whenever mercury or a mercury compound is intentionally used in a product or a process, mercury wastes are created. Wastes containing mercury are often a by-product of major industrial process including burning coal; many large-scale mining activities including left over processed soil (i.e. mining tailings); landfilling; waste incineration; and high-temperature processing of mercury-containing ores and minerals. At many locations, mercury wastes from coal ash, mining tailings, waste incineration and non-ferrous metals processing are directly released into local soils, water bodies, and ground water, which leads to mercury-contaminated sites. Sites on which mercury is intentionally used in manufacturing (such as chlor-alkali and VCM production) can also become contaminated through poor handling procedures for mercury.

Contaminated sites also arise from small scale activities such as artisanal gold mining yet can have a significant impact on human health, especially where such activities are conducted close to local communities and contaminate local food supplies such as fish from local lakes or rivers. While individual miners may only use small quantities of mercury the cumulative impacts of thousands of miners using this method creates major environmental problems and many contaminated sites. The ability of mercury to volatilize at room temperature means that mercury contaminated sites cause local impacts as well as contributing to the overall global load of atmospheric mercury contamination.

What does the mercury treaty say about contaminated sites?

The mercury treaty creates a number of opportunities to initiate action on mercury contaminated sites.

Parties shall "Endeavor"

According to the text of Article 12 of the treaty, Parties "shall endeavor" to take action to address contaminated sites. The term 'endeavor' is defined as "a conscientious or concerted effort toward an end; an earnest attempt" or "trying very hard to achieve something".[355] In other words countries are expected to make a serious effort to take action on mercury contaminated sites and there are a range of actions which are available to them.

355 Collins British Dictionary on-line (2013) http://www.collinsdictionary.com

Guidance on Managing Contaminated Sites

Article 12 obligates the Conference of the Parties (COP) to develop guidance on how to manage mercury contaminated sites including the following topics:

- Site identification and characterization.
- Engaging the public.
- Human health and environmental risk assessments.
- Options for managing the risks posed by contaminated sites.
- Evaluation of benefits and costs.
- Validation of outcomes.

The contaminated sites guidance can be used as the framework for national strategies to address these sites. As yet there is no deadline for development of such guidance.

National Action Plan on mercury waste from Small-Scale Gold Mining

In countries which have 'more than insignificant' levels of ASGM (see Article 7) there is also a requirement to develop a National Action Plan (NAP) to identify, regulate, monitor and reduce mercury use in ASGM. Requirements to address mercury contaminated sites can be built into the NAP and include the same elements that will be established in the guidance documents. This provides an opportunity to embed an entire contaminated sites management framework within the obligatory elements of the NAP.

How NGOs can leverage the treaty for action on contaminated sites.

Accountability & Action

Article 12 provides a platform to highlight the need for addressing mercury waste issues. As mentioned above, countries "shall endeavor" to take action on contaminated sites. This means they must make a concerted effort to manage these sites in an environmentally sound manner. This provides an opportunity for NGOs to hold governments accountable, offer suggestions for action, and publicly question what actions are being taken. There are many low cost, effective actions that government can and should undertake to address contaminated sites. Actions that NGOs can undertake to hold their governments accountable on these commitments are outlined below.

Promote the development of guidance on managing contaminated sites

The mercury treaty requires the COP to develop guidance documentation on how countries can manage contaminated sites. The guidance is to include methods and approaches for:

(a) Site identification and characterization.

(b) Engaging the public.

(c) Human health and environmental risk assessments.

(d) Options for managing the risks posed by contaminated sites.

(e) Evaluation of benefits and costs.

(f) Validation of outcomes.

This process is likely to take some years, but NGOs can help drive the development of guidance for contaminated sites by beginning now to identify and characterize contaminated sites, build awareness through mercury monitoring of soil, fish and human hair and other activities.

In general terms NGOs should advocate for management of mercury contaminated sites through the following simplified framework:

- Identify sites and add to the inventory of mercury contaminated sites.
- Seek containment or demobilization of mercury contamination to prevent it from spreading.
- Treat and remove contaminated material.
- Seek environmentally sound treatment, storage and ultimately disposal of mercury waste.
- For disposal of mercury waste the *Technical Guidelines for the environmentally sound management of wastes consisting of elemental mercury and wastes containing or contaminated with mercury as adopted by the tenth meeting of the Conference of the Parties to the Basel Convention*, can be used as a reference document.

By following the principles of site identification through to the validation of outcomes (testing to ensure the contamination is removed), a national policy to manage mercury contaminated sites is likely to create positive outcomes for other types of contaminated sites because most contaminated sites contain a range of pollutants in addition to mercury. For example, abandoned chlor-alkali plants/facilities are generally contaminated by dioxins and other POPs as well as mercury. In this way, joint efforts between the Stockholm Convention and Minamata Convention to address such sites can begin to be developed.

Identification and characterization of contaminated sites

One of the least costly and most valuable activities a government can undertake to begin the process of addressing contaminated sites is to compile a list of known and inferred[356] sites and attempt to rank them in terms of priority for action (usually determined by the level of risk they present to human health and the environment).

This process is often referred to as identification and characterization. The characterization of sites involves the development of an overall 'picture' of the site including soil, water and air sampling, identification of 'receptors' (humans, flora and fauna), activities undertaken on the site, site history and adjacent land uses. Once the site has been characterized, evaluating the risk to humans and the environment can be undertaken. In some cases the threat to human health and the environment is so severe and obvious that measures should be taken immediately to prevent further impacts.

NGOs can contribute to this process by highlighting known contaminated sites and mercury hotspots in the media while simultaneously raising their country's national obligations under the mercury treaty. NGOs can also encourage governments to set up trilateral committees (made up of industry, government and NGOs) to oversee the compilation of a contaminated site database and to begin the process of developing measures to address contaminated sites. This can include plans to develop contaminated site legislation, address environmental and health impacts and develop policies for community engagement, remediation practices, clean up levels and long-term objectives for contaminated sites.

While this process can be successful in developing broad national policy on contaminated sites it can also be scaled down to help find solutions for individual contaminated sites while giving a voice to the local community who often bear the brunt of the most serious impacts arising from contaminated sites.

Where possible NGOs should begin the process to identify and develop an inventory of known or inferred mercury contaminated sites. This will highlight and

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356 'Inferred' sites is a term to describe sites which are suspected of being contaminated on the basis that the activity undertaken on the site has frequently been associated with contamination at other sites domestically or overseas. An example is a petrol stations site where cars refuel as the storage tanks frequently leak gasoline. In terms of mercury, sites where mercury cell chlor-alkali plants operate or ASGM is undertaken would be deemed 'inferred' sites until monitoring demonstrates them to be mercury free.

promote the need to address mercury contamination at a national level. The data gathered through this activity will also provide a significant body of evidence that can be used in future COP meetings to influence guidance documents.

CASE-STUDY: IPEN-BRI STUDY HIGHLIGHTS THAI MERCURY CONTAMINATION AND DRIVES TRIPARTITE SOLUTION

Most residents in Tha Tum, a rural community in eastern Thailand, are farmers and, because fish are abundant, every household consumes local freshwater fish as a part of their daily diet. However, like many other rural communities, Tha Tum's rapid industrial growth and expansion is compromising public health and the environment.

In Tha Tum, coal dust from open-air storage piles, constant odor from a pulp mill, and massive amounts of dead fish in public canals almost every year triggered serious public concerns that were essentially ignored by both government and industry. Last year, two outspoken environmental activists were assassinated there and many community members believe polluting industries were connected to the deaths.

In 2013, IPEN included the Tha Tum site in its fish and hair monitoring study. The results showed that 85 percent of the fish and 100 percent of the human hair samples contained mercury at levels exceeding health standards. IPEN Thai Participating Organization, EARTH, held a press conference to release the report, and it generated national headlines in print and television media for weeks, making it impossible for government officials to ignore the Tha Tum community's pollution concerns.

Though the government initially disputed the results, the Ministry of Justice launched its own investigation when the Thai Department of Health's own fish and hair tests confirmed IPEN's findings. Ultimately operating licenses at two factories were suspended and 16 factories were cited. Today a tri-partite committee set up by the Ministry of Industry meets monthly and monitors mercury contamination at the site. EARTH is a regular contributor to these meetings, and now a key actor in this new NGO-driven initiative.

Leveraging the treaty requirement for an ASGM National Action Plan (NAP)

NGOs in countries where ASGM is being practiced should push for the development of a NAP for ASGM. The NAP for ASGM must have an objective *to reduce, and where feasible eliminate, the use of mercury and mercury compounds in, and the emissions and releases to the environment of mercury from, such mining and processing*. There is an option to include the management of mercury contaminated sites within the requirements of the NAP. Where possible, NGO's located in a country that is developing a NAP for the purposes of ASGM should campaign to ensure that contaminated site management and clean up becomes a requirement of the plan. This can have flow-on benefits in that many mercury contaminated sites also contain other contaminants that can be removed as part of a clean up plan. The development of principles within the NAP to guide the remediation of mercury contaminated sites can kick-start the development of a national contaminated sites policy. The NAP is also subject to review every three years to assess progress made on mercury reductions.

Accelerate remediation of contaminated sites through NGO advocacy.

NGOs should advocate for the remediation of known mercury contaminated sites irrespective of the provisions of the mercury treaty. IPEN participating organizations have previously undertaken activities that have resulted in governments taking action to reduce mercury contamination in advance of the time-frame stipulated in the mercury treaty. It is also important to remember that undue haste to clean up a site may also result in a poor and dangerous clean up for workers and residents near the site. Special attention should be paid to ensuring that the site is cleaned to internationally acceptable levels of mercury in soil/water and to ensure workers and nearby communities are not impacted by contaminants during the clean up.

Campaign for 'polluter pays' regulations

To be consistent with principles of ecologically sustainable development it is generally accepted that the 'polluter pays' principle should apply to cleaning up contaminated sites. Governments can and do pass legislation that requires polluters to pay for the remediation of sites that they have contaminated. Some countries have 'strict liability' provisions that require companies to pay for the clean up even if decades have passed.

PRECAUTION IS AN INVESTMENT; CONTAMINATED SITE REMEDIATION IS EXPENSIVE

Preventing contaminated sites is a shrewd investment. While some companies may think they are saving money dumping waste products in the environment, 'polluter pays' requirements in legislation or regulations means that the clean up costs can be directed back to the industry that created the contaminated site. Costs can often be in the millions of dollars, which can be a major blow to the profitability of large companies and can affect the viability of smaller businesses. Contaminated sites on a company balance sheet can also deter investors due to the potential clean up costs. Companies should view precautionary action to prevent contamination as a wise investment or face the high costs of clean up in the future.

In some cases no responsible party can be found and the contaminated sites are declared 'orphan' sites. If these sites present a hazard to human health or the environment the government may prioritize and pay for the remediation. In many cases the government itself may be responsible for the contaminated site as part of one of its agency's activities. In these cases the government can be liable for remediation costs. Even in industrially developed countries contaminated site remediation is very expensive. Generally the higher the standard of the cleanup the more expensive it becomes. In the U.S. a 'Superfund' was developed in conjunction with the U.S. government and industry as a means to clean up 'orphan' or 'legacy' sites where the polluter could not be found or had insufficient funds to manage a cleanup. Industries that were commonly known to create contaminated sites (such as the petroleum and chemical industries) contributed to large fund that was required by law to act as a pool of funds to deal with site cleanups. NGOs may consider proposing similar schemes for their country.

A scheme in the Czech Republic was developed during the privatisation of formerly socialised properties to assist with the cost of remediating contaminated industrial sites. Industrial facilities were required to keep an inventory of the chemicals contaminating their land. When the time came to privatise the land/industry a portion of the purchase price of the land was dedicated to a 'fund' that could be used to clean up the land in the future. While it is not strictly a 'polluter pays system,' it could be used successfully in countries with economies in transition to relieve the financial burden on government of remediating multiple contaminated sites.

One of the most difficult contaminated sites funding issues applies to sites, such as ASGM sites, where multitudes of small operations are using mercury either legally or illegally and the cumulative impact of the small operations creates large areas of contaminated land, sediment and surface waters, and possibly even groundwater. In these cases it is almost impossible to identify individuals or groups as the responsible parties. Even if they can be identified most miners are poor and in no position to contribute financially to a site remediation.

However NGOs can campaign for funding to be made available for contaminated site remediation from international sources, especially when their domestic government is not in a position to finance these activities. Both UNEP and the E.U. have participated in providing financial assistance for urgent remediation projects in the past. There may be opportunities for cooperation between NGOs and governments to share information on contaminated sites and support requests for international funding to remediate high risk sites.

Another mechanism for managing cumulative impacts of diffuse contamination is to develop a form of 'extended producer responsibility' policy where the importer and distributor of a product are responsible for its management throughout its lifecycle, including the disposal phase. This has been applied to many consumer products in the past and may be applicable to importers and traders of mercury. By making these entities responsible for their product through to the disposal phase, the cost of remediating mercury-contaminated sites may be directed back to those who profit most from the mercury trade.

Promote contaminated waste clean ups.

A pressing issue facing those responsible for site remediation is what should be done with the contaminated waste arising from contaminated sites when a clean up finally takes place.

Most contaminated site remediation falls into the following categories:

- On-site remediation using treatment technologies.
- 'Dig and dump' operations where the contaminated material is excavated and taken to another place for disposal.
- Natural attenuation – generally a 'do nothing' approach that allows natural processes to degrade the pollutants over time – noting that many contaminants, such as mercury, do not degrade.
- A combination of the above.

All of these methods create varying levels of risk to surrounding communities from contaminated dust and fumes liberated during excavation or from the emissions of treatment technologies. It is important that any site remediation incorporates measures to protect the health of those people living in close proximity to the site.

NGOs can play a key role in addressing this problem by taking a long-term view of how best to manage contaminated sites in their country. In terms of ecologically sustainable development, the 'proximity principle' for dealing with waste suggests it should be treated as close to its source as possible. This prevents problems arising from transporting waste over large distances and recreating the problem in another area where there may be no technical or financial capacity to manage it. However, there are many cases where the community adjacent to a contaminated site remediation has suffered health impacts due to the release of toxic materials during the clean up. Some situations may just be too dangerous to allow on-site treatment.

VULNERABLE COMMUNITIES MUST BE PROTECTED FROM DUMPING.

When advocating for the remediation of mercury contaminated sites it is critically important that any agreement or policies to clean up a site(s) prevents the dumping of the waste in communities that are least able to take measures to protect themselves from its negative impacts. Dumping or stockpiling waste from contaminated sites in impoverished areas can exacerbate mercury pollution impacts by impacting on the most vulnerable in society. People living in poverty are often malnourished, reliant on local food sources that may become contaminated, lack healthcare, education and political advocacy.

It is important for NGOs to develop a position on these overall principles of managing contaminated sites and communicate them to government before major policies are put in place that may be difficult to influence at a later point in time. It is also preferable to debate and where possible, resolve these issues *before* excavators start digging up contaminated sites and looking for places to dump the waste. As the waste tends to be dumped in the area of least resistance and poor communities with limited education, health care, political representation and therefore social influence can be targeted for disposal sites. If poor sites are chosen for final disposal of contaminated wastes the environmental and human health impacts may be shifted or amplified in the process of cleaning up a site resulting in no net benefit.

NGOs should advocate for the clean up of contaminated soil to a specific, acceptable level of mercury and track what happens with the mercury recovered from the clean up (resulting mostly from indirect thermal desorption). Clean up of soil prior to its dumping and/or use reduces the volume of wastes highly contaminated by mercury and it can also reduce the risks to specific smaller area, which can be better controlled (see also section 11.4 on long term storage). It is also very important to remember that any proposal to clean up a mercury-contaminated site by incineration, roasting or direct thermal desorption should be avoided at all costs. While the soil may be cleaner at the end of these processes it is highly likely that mercury vapor will be emitted at high levels to atmosphere and that dangerous POPs such as dioxins and furans will be created and released.

11.1 PRODUCT WASTES

Much of the mercury content of mercury-containing products is released into the environment at the end of the products' useful life. When the product is incinerated, mercury is released into the incinerator's flue gas. Air pollution control devices (APCDs) capture some of the mercury, but the rest is released into the atmosphere. Mercury captured by APCDs is also sometimes subsequently re-released into the environment. Incineration of waste or products containing mercury always results in the generation of ash. The ash generated by incinerators (both fly ash and bottom ash) equates to around 30 percent of the original mass of waste incinerated by weight. So incineration of 100 metric tons of waste results in about 30 metric tons of contaminated ash. The ash contains elevated levels of persistent organic pollutants (POPs), heavy metals (including mercury) and many other toxic contaminants. Mercury can volatilize from ash and re-enter the environment. Most ash is directed to landfills and some is used as building and road construction material.

When a mercury-containing product is sent to a waste dump or to an engineered landfill, much of its mercury content will escape into the broader environment. One important pathway by which mercury escapes is through dump fires and landfill fires. However, even in the absence of fires, some of the mercury in dumps and landfills will volatilize and enter the atmosphere. Water-soluble mercury compounds in landfills can leach from the site and enter water systems. Both elemental mercury and mercury compounds can attach to soils and can migrate off the site due to flooding or other conditions.

A report titled "Mercury Rising: Reducing Global Emissions from Burning Mercury-Added Products," produced by the Mercury Policy Project for the Global Alliance for Incinerator Alternatives (GAIA) and other NGO networks, estimates that between 100 to 200 metric tons of mercury were released into the global environment in 2005 from a combination of medical-waste incineration, the incineration of mercury-added products, the incineration of municipal wastewater sludge (with a contribution from mercury-containing products), landfill fires, and the open burning of wastes that contain mercury-containing products.[357]

Mercury from mercury-containing products is also released from waste dumps and landfills even in the absence of fire. It is released from these products in transit on the way to the landfill, from the working face (active portion) of the landfill, during landfill waste-handling operations, and as a contaminant in the landfill gas. The landfill gas, which is mostly methane and carbon dioxide, is burned, harnessed as an energy source, or vented directly into the atmosphere.[358]

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[357] Peter Maxson, "Mercury Rising: Reducing Global Emissions from Burning Mercury-Added Products," for the Mercury Policy Project, February 2009, http://www.zeromercury.org/International_developments/FINAL_MercuryRising_Feb2009.pdf.

[358] "Summary of Research on Mercury Emissions from Municipal Landfills," NEWMOA factsheet, 2009, http://www.newmoa.org/prevention/mercury/landfillfactsheet.cfm.

One study found mercury at greater than 10 times background levels in 20 of 200 dumpsters used in transporting waste to a landfill. The mercury levels reached approximately 500 nanograms (ng) per cubic meter in these dumpsters. Another study measured mercury concentrations upwind and downwind of the working face at several landfills and found downwind mercury concentrations significantly elevated over upwind concentrations—often 30 to 40 times higher. Some measurements reached 100 ng of mercury per cubic meter downwind. Researchers also measured the mercury content of landfill gas and found concentrations ranging from a few hundred to several thousand ng per cubic meter.[359]

A study at a landfill site in China measured total gaseous mercury (TGM) in landfill gas and also measured both monomethylmercury and dimethylmercury concentrations in the landfill gas. It found concentrations of TGM in the landfill gas of approximately 665 ng per cubic meter and found combined concentrations of monomethylmercury and dimethylmercury of about 11 ng per cubic meter. The report indicates further that mercury is released directly from landfill soils but no measurements were taken.[360] Another Chinese study found concentrations of TGM in landfill gas as high as 1,400 ng per cubic meter and calculated that the annual amount of mercury contained in the landfill gas escaping from the landfills being studied was as high as 3,300 g of mercury per year.[361] More work is certainly needed to measure mercury emissions and releases from both engineered landfills and also large waste dumps.

According to the UNEP report "Summary of Supply, Trade and Demand Information on Mercury" from 2006, the estimated amount of mercury used in products was as follows:[362]

359 Ibid.

360 Xinbin Feng et al., "Landfill Is an Important Atmospheric Mercury Emission Source," *Chinese Science Bulletin*, 2004, http://www.springerlink.com/content/t1k8j12r71k091r5/.

361 Z.G. Li et al., "Emissions of Air-Borne Mercury from Five Municipal Solid Waste Landfills in Guiyang and Wuhan, China," *Atmospheric Chemistry and Physics*, 2010, http://www.atmos-chem-phys.org/10/3353/2010/acp-10-3353-2010.pdf.

362 "Summary of Supply, Trade and Demand," UNEP, cited above.

2005 MERCURY DEMAND FOR USE IN PRODUCTS (IN METRIC TONS)

Product	Low Estimate	High Estimate
Batteries	300	600
Dental Use	240	300
Measuring and Control Devices	150	350
Lighting	100	150
Electrical and Electronic Devices	150	350
Other	30	60
Total	970	1,810

Since 2005, mercury use in batteries has declined while mercury use in lighting has increased. Nonetheless, the amount of mercury added to new products each year likely remains above 1,000 metric tons per year.

Each mercury-containing product has a time-limited useful life after which it is either discarded as a waste or, alternatively, some or all if it is recovered for reuse or recycling. Unfortunately, often when electronics wastes are processed for recovery and recycling, mercury-containing devices are broken up and/or heated, which releases mercury fumes into the workplace and the atmosphere. It appears also that only a small fraction of the waste from end-of-life mercury-containing products is responsibly managed in ways that capture the mercury content of the product and prevent its subsequent environmental release.

The long-term solution to the problem of mercury wastes and mercury-contaminated sites is prevention, the phase out or minimization of mercury-containing products and processes, and strict limits and controls on unintentional anthropogenic mercury sources. In the interim, mercury-containing discards need to be better managed. The enterprises that produce or sell mercury-containing products should be required by law to take them back at the end of their useful life and to ensure the discarded material is responsibly managed in ways that minimize mercury releases into the environment. In particular, measures should be put in place to ensure that mercury-containing end-of-life products are not incinerated or openly burned, are not sent to dumps or landfills likely to become subject to landfill fires, and are not sent off for electronics-waste reprocessing at locations that are not equipped to properly manage the mercury content of the waste.

What does the mercury treaty say about mercury and product wastes?

The mercury treaty addresses some of these issues by requiring a phase out of many mercury added products by 2020 under Article 4 (with potential exemptions until 2030) and by developing guidance on mercury contaminated sites (Article 12) and mercury waste management (Article 11).

11.2 MERCURY PROCESS AND BY-PRODUCT WASTES

Information related to mercury-process and by-product wastes has already been presented earlier in this booklet in sections addressing mercury supply, small-scale gold mining, mercury-cell chlor-alkali plants, the use of mercury catalysts in producing vinyl chloride monomer, coal-fired power plants, cement production, industrial-scale metals mining and refining, and other sections.

Some industrial gold and zinc mining and refining operations recover commodity-grade elemental mercury from their by-product wastes. Commodity-grade elemental mercury is also sometimes recovered from chlor-alkali plant wastes, from spent catalysts used in VCM manufacture and, in some cases, even by small-scale gold miners and gold merchants. The recovered commodity-grade elemental mercury is either reused in the process, reenters the market, or is removed from the market and placed into long-term and/or interim storage facilities.

Most often, however, industrial and other processes that use mercury as well as those that unintentionally generate mercury wastes do not recover commodity-grade elemental mercury and generally do an inadequate job in preventing their mercury wastes from entering the environment.

The mercury treaty and The Basel Convention have yet to determine relevant threshold concentrations for waste that is deemed to be 'mercury waste,' but will provide guidance on this issue at a later stage. It is likely that the low mercury limit threshold concentration that will define mercury waste will be decided in conjunction with the relevant bodies of the Basel Convention. It may be expected that the level will be harmonised between the two conventions. Many aspects of Article 11 of the mercury treaty place the onus for managing mercury waste upon individual countries and defer to their existing domestic waste management regimes. Further information on Article 11 is provided below.

Until new guidance on waste definitions for the mercury treaty is finalized, existing Basel Convention technical guidelines can be used. The Basel Convention has developed "Technical Guidelines for the environmentally sound management of wastes consisting of elemental mercury and wastes containing or contaminated with mercury" adopted by the tenth meeting of the Conference of the Parties to the Basel Convention.

What does the mercury treaty say about mercury waste?

The mercury treaty requires that Parties take measures to ensure that mercury waste is managed in an environmentally sound manner taking into account the existing waste management regulations of individual countries. Guidance will be developed in the next few years on how different forms of mercury wastes should be managed. Currently, there is some difficulty in defining mercury wastes other than elemental mercury (such as mercury arising from chlor-alkali plant closures which is not permitted to be traded).

The issue of identifying waste containing mercury will be resolved when the COP develops guidance on the concentration threshold for mercury levels in waste. Once this concentration is determined any waste material with a concentration above that threshold will be deemed mercury waste and must be managed according to the guidance for environmentally sound management of mercury waste as outlined in the Basel Convention and with additional guidance from the COP of the mercury treaty. It should be noted that the Basel Convention has an objective related to the international movement of hazardous waste whereas the mercury treaty has an objective based on the protection of human health and the environment. As a result the mercury concentration threshold that defines mercury waste for the mercury treaty may differ from Basel Convention thresholds and this issue will form a part of the international discussions to determine the threshold. It is worth noting that there is no threshold for mercury in waste defined by Basel Convention yet.

Elemental mercury that is reclaimed from mercury waste can be re-used as long as it is directed to an allowed use under the mercury treaty.

The mercury treaty also includes mining tailings (from any form of mining) as mercury wastes if they contain concentrations above the yet to be determined threshold.

Article 11 Mercury wastes

- The treaty applies the Basel Convention definitions of waste to the mercury treaty: wastes consisting of or containing mercury compounds or contaminated with mercury or mercury compounds.

- The COP in collaboration with the Basel Convention will decide the relevant thresholds for determining the relevant quantities of mercury in wastes that make it hazardous.
- The treaty specifically excludes tailings from mining (except primary mercury mining) unless the wastes contain mercury above the thresholds defined by the COP. This covers tailings containing mercury from all types of mining operations.
- Parties are to "take measures" so that mercury waste is managed in an environmentally sound manner according to Basel Convention guidelines and future guidelines that will be added to the treaty.
- No corporate or polluter responsibility is identified in the Article, however national governments may wish to make use of these economic instruments.
- In developing waste guidelines, the COP must take national waste management programs and regulations into account.
- Mercury waste can only be recovered, recycled, reclaimed, or directly used for a use allowed under the treaty. Note: mercury from decommissioned chlor-alkali plants is regulated separately under Article 3 (Supply and Trade).
- Basel Convention Parties are not permitted to transport waste across international boundaries except for environmentally sound disposal.
- Non-Basel Parties are to take into account relevant international rules, standards and guidelines.

Taking action on mercury wastes

The mercury treaty requires Parties to "take measures" to ensure the environmentally sound management of mercury waste. NGOs can therefore ask their government to articulate exactly what measures they have taken to comply with this requirement. Most elements (but not all) of these measures are defined in the "Technical Guidelines for the environmentally sound management of wastes consisting of elemental mercury and wastes containing or contaminated with mercury" as adopted by the tenth meeting of the Conference of the Parties to the Basel Convention.

Holding government accountable on mercury waste 'measures'

Measures can include a range of activities from developing actual physical infrastructure such as disposal sites or mercury waste treatment facilities to policy development, legislation, regulations and monitoring. Governments should be transparent about the activities they are undertaking to ensure that mercury waste is managed in an environmentally sound manner. Their activities can also include cooperation with international bodies to develop and maintain capacity for dealing with mercury waste in this manner. NGOs should encourage their government to take advantage of the technical expertise that may be available through such bodies to accelerate the responsible management of mercury waste in their country.

The mercury treaty does require that Parties existing waste management regulations and programs be taken into account. However, if, for example, a country relies solely on landfill to dispose of mercury waste, which is an environmentally unsound practice, then there is scope for NGOs to argue that stronger measures are required to manage mercury waste to ensure it does not contaminate groundwater through leachate and air through mercury vapor release.

Identification of known mercury wastes

While a threshold concentration of mercury has not yet been defined by the COP to positively identify mercury waste, there are activities NGOs can undertake to highlight poor management of mercury waste while a determination on a low mercury limit is debated.

IPEN and Arnika have published a map "Selected ***Mercury Waste Hot Spots*** around the World."[363]This map can serve also as a starting point and template for similar effort at the national level for NGOs.

Any country with significant mercury levels will have mercury waste requiring special management. In many cases a mercury concentration analysis will not be needed to determine whether or not the materials should be classified as mercury waste. Some of the more obvious materials include products containing mercury such as CFLs, fluorescent tubes, thermometers, certain batteries and so on. NGOs should advocate for immediate measures to regulate the handling of these products in the waste phase when it is mostly likely that they will release mercury contamination. Specialized servers such as sciencedirect.com or, more generally, scholar.google.com are among the many resources that provide information about mercury waste and country and/or regional based information about waste.

Key precautionary activities government should undertake (irrespective of deliberations on the mercury concentration threshold) are the establishment of regulations to ensure that these type of materials are segregated from the rest of the waste stream and collected for further treatment, recycling (for allowed uses) or environmentally sound disposal. Technologies to safely recycle glass and recover

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[363] http://www.ipen.org/sites/default/files/documents/mercury_waste_hotspots_world_map-en.pdf

mercury from CFLs and thermometers have been in use for some time. NGOs can promote public/private investment to attract companies that will establish these technologies to better manage mercury waste in these products.

NGOs could also consider approaching industry associations whose members manufacture or sell these products and encourage them to engage in product stewardship programs to ensure that these products are collected and managed safely at the end of their useful lives including investment in recycling technologies mentioned above.

All of these activities can be undertaken without waiting for the mercury treaty to come into force or for low mercury limit to be established.

Taking action on suspected mercury wastes

Some wastes containing mercury are more difficult to identify without laboratory analysis or instruments such as an XRF device. These may include mercury contaminated recycled metals, industrial sludge, ash, contaminated soil, mining tailings and liquid wastes. The status of many waste streams of this nature will be determined once a threshold concentration for defining mercury waste is determined.

In the meantime there are many wastes that NGOs can identify that are 'suspect' until proven otherwise by analysis. There are many industrial processes that use mercury or create waste streams commonly known to contain mercury, which may be identified on a NGO list of possible mercury wastes for further investigation.

Fly ash from municipal, medical and hazardous waste incinerators are known to contain elevated levels of mercury. Similarly coal ash from power plants is also known to be contaminated with mercury. For those waste streams that have a known history of mercury contamination, identification of current waste dumps for this material by NGOs can be added to a database of potentially mercury-contaminated sites. Those NGOs with analytic capability and access to dump sites also may be able to sample those dumps and publicly highlight any elevated mercury levels to put pressure on industry and government to clean up sites and tighten regulation on those industries.

IDENTIFYING CONTAMINATED WASTE: VLORA MERCURY HOT SPOT IN ALBANIA

Vlora Bay is part of the Adriatic Sea and located in the southwestern part of Albania. The former chlor-alkali and PVC plant in Vlora (known as the Soda PVC plant) is the most significant source of mercury contamination in Vlora Bay. The plant started operation in 1967 and used a mercury cell process to produce caustic soda and PVC. At its peak, the plant produced 24,000 metric tons of calcinate soda, 15,000 metric tons of caustic soda, and 10,000 metric tons of PVC. Soda PVC Plant discharged its waste directly into Vlora Bay and also dumped polluted sludge on a site near the seashore. The plant was closed in 1992 and its buildings have been completely destroyed since that time. However, the dumped sludge remains near the shore with no precautions taken to prevent further contamination of the Bay or nearby residents. In 2002, an identification mission of UNEP/MAP (GEF Project GF/ME/6030-00-08) identified this area as a "hot spot" after a soil sample found mercury levels greater than 10,000 ppm in the area of the former plant - 1,000 times greater than typical E.U. thresholds.

Vlora Bay is an important fishing area and fish from the area are distributed to all cities in Albania. Sampling of the fish by IPEN and Arnika found average mercury levels in mullet are 2.8 times higher than the U.S. EPA reference dose of 0.22 ppm. The maximum mercury values observed in mullet are more than four times higher than the reference dose. Four of the cod samples also exceeded the reference dose.

To prevent continuous mercury pollution of sea ecosystems and fish serving as food for the local community and tourists in Vlora, it is necessary to prevent further releases from the contaminated area and wastes into the sea. Until this problem is addressed, mercury will continue to contaminate both the local area and contribute to global mercury pollution.

Examples such as Vlora can be used to highlight the impacts of mercury waste on human health and the environment and increase pressure on authorities to access funding to clean up these sites. It is important that all aspects of site clean up (including the destination of recovered wastes) are carefully audited to make sure that the remediation technologies do not release mercury emissions or generate POPs emissions such as dioxins and furans. In particular technologies using direct roasting or incineration should be avoided.

Mercury waste treatment technologies

There are many different technologies suggested to treat mercury waste in order to reduce the content of the mercury. Most of them are listed in technical guidelines adopted by Basel Convention. In the case of mercury caution is urged with regard to any thermal treatment. Mercury evaporates very easily and some of the technologies promoted under other names are simply forms of waste incineration. The most problematic technologies are different roasting and *direct* thermal desorption (where waste is directly heated) technologies.

Even in cases when some device to capture mercury is applied, attention must be paid to chlorine and other halogen compounds in the wastes that will form dioxins and other POPs releases when incinerated or roasted in any form. The only safe technology is *indirect* thermal desorption, where waste is not directly burned. Instead the contaminated waste is indirectly heated and the mercury separated and captured. IPEN advocated for this aspect of waste treatment to be incorporated into the "Technical Guidelines for the environmentally sound management of wastes consisting of elemental mercury and wastes containing or contaminated with mercury", as adopted by the tenth meeting of the Conference of the Parties to the Basel Convention.

11.3 MERCURY IN CONTAMINATED SOILS AND WATER

Once mercury contamination is present in soils or in water, all available options for cleanup and remediation are very expensive and are also less than fully satisfactory. In some cases, methods used to clean up contaminated soils and water merely shift the mercury to another medium. For example, some technologies promote the volatilization of mercury from soil or water into the air. In 2007, the U.S. EPA released a report entitled "Treatment Technologies for Mercury in Soil, Waste, and Water" that describes some of the available options.[364]

The report uses the term *soil* to include soil (a mixture of sand, silt, clay, and organic matter), debris, sludge, sediments, and other solid-phase environmental media. It uses the term *waste* to include non-hazardous and hazardous solid waste generated by industry. It uses the term *water* to include groundwater, drinking water, nonhazardous and hazardous industrial wastewater, surface water, mine drainage, and leachate. The following table is a summary of treatment technologies available in the U.S.

[364] "Treatment Technologies for Mercury in Soil, Waste, and Water," U.S. EPA Office of Superfund Remediation and Technology Innovation, cited above.

Technology	Description
Solidification/ Stabilization	Physically binds or encloses contaminants within a stabilized mass and chemically reduces the hazard potential of a waste by converting the contaminants into less soluble, mobile, or toxic forms.
Soil Washing/ Acid Extraction	Uses the principle that some contaminants preferentially adsorb onto the fines fraction of soil. The soil is suspended in a wash solution and the fines are separated from the suspension, thereby reducing the contaminant concentrations in the remaining soil. Acid extraction uses an extracting chemical, such as hydrochloric acid or sulfuric acid.
Thermal Desorption/Retorting	Application of heat and reduced pressure to volatilize mercury from the contaminated medium, followed by conversion of the mercury vapors into liquid elemental mercury by condensation. Off-gases may require further treatment through additional air pollution control devices such as carbon units.
Vitrification	High-temperature treatment that reduces the mobility of metals by incorporating them into a chemically durable, leach-resistant, vitreous mass. The process also may cause contaminants to volatilize, thereby reducing their concentration in the soil and waste.

The report indicates that the solidification/stabilization (S/S) process is the most frequently used technology in the U.S. to treat soil and waste contaminated with mercury. S/S is a commercially available technology that has been used to meet regulatory cleanup levels. The technologies listed in the report other than S/S technologies for treating mercury-contaminated soils and wastes are less frequently used than S/S technologies and are typically used only for specific applications or soil types. The authors of the report provided no information on the long-term stability of mercury-containing soil and wastes treated using S/S, and they indicated that they did not have the data necessary to provide this information.

More information is certainly needed, not only on the stability of mercury wastes treated with S/S technologies but also, more generally, on the long-term fate of the mercury content of the residues associated with all mercury-waste-treatment technologies. Concerns remain about mercury off-gassing from these residues into the atmosphere over time. Concerns also remain about other pathways through which mercury is released from these residues into the environment.

TECHNOLOGIES FOR WATER TREATMENT

Technology	Description
Precipitation/Co-Precipitation	Uses chemical additives to (a) transform dissolved contaminants into an insoluble solid, or (b) form insoluble solids onto which dissolved contaminants are adsorbed. The insoluble solids are then removed from the liquid phase by clarification or filtration.
Adsorption	Concentrates solutes at the surface of a sorbent, thereby reducing their concentration in the bulk liquid phase. The adsorption media is usually packed into a column. Contaminants are adsorbed as contaminated water is passed through the column.
Membrane Filtration	Separates contaminants from water by passing the water through a semi-permeable barrier or membrane. The membrane allows some constituents to pass, while it blocks others.
Biological Treatment	Involves the use of microorganisms that act directly on contaminant species or create ambient conditions that cause the contaminant to leach from soil or precipitate/co-precipitate from water.

Of the water-treatment technologies described above, precipitation/co-precipitation is the most commonly used process in the U.S. to treat mercury-contaminated water, often changing properties of the water such as its acidity (pH) or changing the chemical properties of the mercury (Hg2+ to Hg0) to allow for better removal rates. The effectiveness of this technology is less likely to be affected by characteristics of the media and contaminants compared with the other listed water-treatment technologies.

Adsorption tends to be used in cases when mercury is the only contaminant to be treated, for relatively smaller systems, and as a polishing technology for effluent from larger systems. Membrane filtration is less frequently used because it tends to produce a larger volume of residues than do other mercury-treatment technologies. Bioremediation appears to be limited to pilot-scale studies.

11.4 INTERIM STORAGE AND DISPOSAL OF MERCURY

In the section of this booklet called Mercury Supply, it was noted that both the European Union and the United States have adopted laws or regulations that will ban exports of elemental mercury. In some circumstances, this will require long-term mercury management and storage; in others it will require mercury disposal that is safe for human health and the environment. E.U. regulations classify as waste all mercury recovered from mercury-cell chlor-alkali plants and also mercury recovered from nonferrous mining and smelting operations and the cleaning of natural gas. This means that commodity-grade elemental mercury that is derived from these sources in E.U. countries cannot be sold or used, but instead must be disposed of.

In the United States, the export ban will mean that all supplies of commodity-grade elemental mercury in excess of demand will need to go into storage. Ongoing sources of mercury supply in the United States include mercury that has been recovered from the conversion or closure of chlor-alkali plants, mercury recovered as a by-product from gold mining and certain nonferrous metals refining, mercury recovered from product-collection programs and other recycled mercury.

According to a UNEP assessment report, in the Latin American and Caribbean Region, the increasing capture of by-product mercury from mining operations and the increasing use of alternatives to replace mercury will result in excess mercury in the region. Governments in the region recognize that this excess mercury must be managed properly and stored to prevent its reentry into the global market. These governments consider identifying environmentally sound storage solutions for mercury a priority.[365]

Although other regions, such as Asia, do not currently appear to have an excess of mercury supply over demand, it is anticipated that this will change after the new mercury treaty provisions enter into force. It is therefore expected that all regions will need to have programs in place to remove excess mercury supply from the market in order to prevent cheap excess mercury from becoming available for inappropriate uses, especially by sectors where legal restrictions on mercury use may be difficult to enforce, such as small-scale gold mining.[366]

The preferred mercury-storage method in some countries, such as the United States, is aboveground monitored storage. For example, the U.S. military has a large stockpile where mercury is stored in 76-pound flasks. These flasks, in turn, are sealed in airtight 30-gallon drums. There are six flasks per drum and five drums per pallet. Inside the drums, the flasks are individually sealed in plastic bags, separated by dividers, and placed on an absorbent mat that doubles as cushioning material. The drums rest on catch trays on wooden pallets on sealed floors. The pallets are not stacked in order to facilitate inspection and air monitoring.[367] This is likely to be an adequate approach to prevent mercury from escaping the warehouse, so long as there is adequate maintenance and monitoring, the warehouse does not become subject to a natural disaster such as an earthquake,

[365] "Assessment Report: Excess Mercury Supply in Latin America and the Caribbean, 2010-2050," UNEP Chemicals, July 2009, http://www.chem.unep.ch/mercury/storage/main_page.htm.

[366] "Development of Options, Analysis and Pre-Feasibility Study for the Long Term Storage of Mercury in Asia and the Pacific," UNEP, February 2010, http://www.chem.unep.ch/mercury/storage/main_page.htm.

[367] "Background Paper for Stakeholder Panel to Address Options for Managing U.S. Non-Federal Supplies of Commodity-Grade Mercury," U.S. EPA, March 2007, http://www.epa.gov/mercury/stocks/backgroundpaper.pdf.

flooding, or cyclone force winds and so long as the area where the warehouse is located does not become a war zone. Other mercury-storage options in use in the U.S. include storing it in metric ton flasks and in plastic bottles.

In the European Union, regulations call for permanent or temporary storage of elemental mercury in salt mines adapted for the disposal of metallic mercury or in deep underground, hard rock formations if it is determined that they provide a level of safety and confinement equivalent to that of salt mines. Regulations also permit temporary storage of mercury for more than one year in aboveground facilities dedicated to and equipped for the temporary storage of metallic mercury.[368]

For mercury storage in salt mines, the E.U. regulations state that the rock surrounding the waste should act as host rock in which waste is encapsulated. The storage site must be located between overlying and underlying impermeable rock strata to prevent groundwater from entering and liquids and gases from escaping. Shafts and boreholes must be sealed during operation, and they must be hermetically closed after operation. The disposal area must be sealed with a hydraulically impermeable dam when there is ongoing mineral extraction at the mine. The stability of the host rock must be assured during operation, and the integrity of the geological barrier must be assured over unlimited time.[369]

E.U. regulations also permit mercury storage in hard rock formations. These are defined as underground storage areas at several hundred meters depth made of hard rock, which includes various igneous rocks such as granite or gneiss and also sedimentary rocks such as limestone and sandstone. Temporary or permanent mercury storage is permitted in such facilities only if it is determined that the facility provides a level of safety and confinement equivalent to that of salt mines. Other conditions also apply. The disposal facility must be adapted for the disposal of metallic mercury. It must provide for protection against mercury releases into groundwater and must protect against mercury vapor emissions. The site must be impermeable to gasses and liquids. The construction must be passive with no need for maintenance. It should allow for recovery of waste and future corrective measures. It should be stable for an extended period of time, up to thousands of years. And the storage site must be located below the groundwater table so there can be no direct discharge of pollutants into the groundwater.[370]

Other countries and regions are considering what options they may have for long-term storage of elemental mercury.

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368 "Requirements for Facilities and Acceptance Criteria for the Disposal of Metallic Mercury," European Commission, April 2010, http://ec.europa.eu/environment/chemicals/mercury/pdf/bipro_study20100416.pdf.

369 Ibid.

370 Ibid.

According to a draft outline report prepared for UNEP and presented to an April 2010 regional meeting for countries of the Latin American and Caribbean region,[371] some of the requirements for an aboveground special engineered warehouse include the following:

- The location must not be susceptible to earthquake, hurricanes, and flooding.
- More than one area should be considered.
- Dry locations are preferred.
- The site should be distant from any water basin or populated area.
- Mercury containers should be protected against groundwater.
- Vapor emissions should be prevented through packaging, handling, internal transportation, and temperature control.
- The site should be protected from groundwater and surface-water contamination.
- The site should be near roads or transportation infrastructures.
- Programs should be in place to prevent risks and accidents.
- Storage should be reversible.
- Systems should be in place to monitor the air, the containment, workers' blood and urine, etc.
- There should be emission controls on the facility.
- The facility should have permanent mercury vapor monitoring with a sensitivity ensuring that the indicative limit value of 0.02 mg mercury/m^3 is not exceeded.
- The facility should have a program for spill prevention and control.
- Packing standards need to be established.
- Buildings should have mercury-resistant sealed floors, and they should slope towards a collection sump.
- Facilities should have adequate security measures.
- Mercury should not be stored with other wastes.

[371] "Draft Annotated Outline: Developments of Options Analysis and Feasibility Study for the Long Term Storage of Mercury in Latin America and the Caribbean," UNEP, 2010, http://www.chem.unep.ch/Mercury/storage/LAC_Docs/First%20%20Draft%20report%20feasibiity%20study%20Hg%20storage%20LAC%20project%2005-04-10%20parcial.doc

- There should be yearly maintenance checks and yearly calibration of monitoring systems.
- The facility should be subject to regular independent audits.

Experts from the E.U. additionally noted that with aboveground storage, mercury still remains in the biosphere. They noted also that the safety of this option depends on political stability and that aboveground storage may not be a permanent solution.

The draft report also discusses underground disposal. The main consideration in underground disposal is to isolate waste from the biosphere in geological formations where it is expected to remain stable over a very long time. This is best done deep underground. Mercury is placed into containers before being put into the mine. Its containment and isolation is achieved by the containers, by additional engineered barriers, and by the natural barrier provided by the host rock. The draft report indicates that the most common rock or soil types used for underground disposal include clay and salt as well as hard magmatic, metamorphic, or volcanic rocks such as granite, gneiss, basalt, or tuff. The depth depends on the type of formation used and the isolation capacity of the overlying formations.

The draft report identifies some requirements (not all of which are mutually compatible) for underground waste storage in old mining sites:

- It should be an available, unused, excavated area of a mine that is remote from areas where active mining is taking place and can be sealed off from active mining areas.
- The cavities will need to remain open so the mine operator cannot have a backfill obligation.
- The mined cavities must be stable and accessible even after a prolonged time.
- The mine must be dry and free of water.
- The cavities in which the waste is to be stored must be sealed off from water-bearing layers.
- To improve safety and to simplify mercury handling, the mercury should be stabilized, that is, it should be chemically treated to transform elemental mercury into mercury sulphide.
- Mercury purity must be higher than 99.9 percent because impurities result in increased water solubility.
- There should be no oxidizing agents present in the vicinity of the mercury.

- Because mercury has high vapor pressure, the facility needs good handling and ventilation systems.
- The waste acceptance criteria will depend on the local legal framework.[372]

An Asian regional meeting also reviewed options for long-term mercury storage. A report prepared by several Asian institutions and organizations for the meeting considered three options: above-ground specially engineered warehouses, underground geological formations such as salt mines and special rock formations and export to foreign facilities. The report's authors concluded that the most important requirements for long-term mercury management are dry atmospheric conditions; political, financial and economic stability; security; appropriate infrastructure and environmental security.[373]

The authors recommend that the establishment of mercury storage facilities should go hand-in-hand with efforts to establish facilities to process mercury-rich wastes. They note that this will be costly and that special mechanisms will be needed to address both financial costs and legal aspects.

The authors of the Asian report suggest that countries that have deserts and a stable socio-political situation should give consideration to hosting an aboveground storage facility. They recommend, however, that countries in Asia should not pursue the use of underground geological formations for storing mercury because of its high costs and the lack of appropriate sites. The authors recommend that countries without deserts and those with potentially unstable conditions export mercury and mercury-rich wastes to countries where safe, long-term mercury storage facilities can be arranged.[374]

The mercury treaty provides for future adoption of measures to guide storage of mercury both as an interim measure and for permanent disposal under Article 10 with the expectation that mercury will be stored in an environmentally sound manner.

Article 10 Environmentally sound interim storage of mercury, other than waste mercury

- Interim storage of mercury can only be for a use allowed under the treaty. The interim storage has a similar function as the storage of mercury stocks.

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[372] Ibid.

[373] "Development of Options, Analysis and Pre-Feasibility Study for the Long Term Storage of Mercury in Asia and the Pacific," UNEP, cited above.

[374] Ibid.

- Parties must “take measures” to ensure that interim storage mercury is carried out in an environmentally sound manner and ensure that these facilities do not become mercury hotspots.
- The COP is to adopt guidelines on storage taking Basel Convention Guidelines into account but the treaty does not specify when these guidelines have to appear. These guidelines should address various types of interim storage, including national or regional interim storage.
- The guidelines on storage may be added as an annex to the treaty.

NGOs can use the mercury treaty to ensure that mercury is stored in an environmentally sound manner

Interim storage of mercury will become an important issue for NGOs as they work with their governments to remove mercury from the trade and supply cycle. The mercury treaty places an obligation on Parties to “take measures” to ensure that interim storage of mercury is carried out in an environmentally sound manner. NGOs should question their government as to what measures have already been taken in terms of processes to determine a suitable site for a storage facility. If the government already has facilities for mercury storage NGOs can audit the operation of these facilities against a ‘check list’ such as those developed for the Latin American and Caribbean region and cited earlier in this section.

As guidance emerges from the mercury treaty COP on specific criteria for interim storage of mercury, NGOs can directly check the conditions at their regional or national storage facilities for compliance. If NGOs have doubts about the integrity of a storage facility, mercury sampling of soil or air could be conducted at the boundary of the facility to highlight any problems with mercury contamination and storage inadequacies.

Interim storage (which differs from long term storage) applies to two distinct scenarios:

1) Where mercury is to be stored as a stockpile for an ‘allowed use’ under the mercury treaty (mercury cannot be stored and directed to a use that is not allowed).

2) Where mercury is stockpiled in order to remove it from circulation in the trade and supply chain, pending permanent disposal.

In either circumstance it is important that a secure facility meeting the environmentally sound storage guidelines is developed to prevent vapor release, leaks and other forms of contamination that may affect the health of facility workers or the surrounding population and environment.

Elemental mercury may arise from numerous sources especially if restrictions are placed on the trade of mercury within a country and as an export. The closure of chlor-alkali plants, scrapping and recycling of products containing mercury (e.g. fluorescent tubes), mercury stripped from stack emissions, metal refining or gas cleaning and mercury removed from medical settings, will all need to be subject to environmentally sound storage pending a permanent disposal option.

NGOs should, as a priority, seek action from their regulatory authorities at a national or regional level, to initiate the process to site a mercury storage facility. The co-location of mercury storage facilities with major mercury recovery sites (such as contaminated chlor-alkali facility sites) has been suggested as a means to prevent mercury from being transported over large distances with an increased risk of spills or pollution. The criteria for siting mercury storage facilities discussed earlier in this section highlight the need for the storage facility to be as stable as possible in geological and political terms and not easily subject to the destructive forces of natural disasters such as floods, hurricanes and seismic activity.

Mercury waste will be defined by the COP at a later date in conjunction with the Basel Convention arrangements. Essentially this means that the COP of the mercury treaty will work cooperatively with relevant bodies of the Basel Convention to determine low mercury content thresholds for characterizing wastes. Those wastes containing mercury at levels above the threshold concentration (which is yet to be determined) are to be disposed of according to the provisions of the mercury treaty or domestic legislation.

The mercury treaty allows used mercury and mercury wastes (with the exception of mercury arising from chlor-alkali plant closures) to be recycled and reprocessed for further use *only if it is to be directed toward an allowed use*. Elemental mercury that is not intended for an allowed use must be subject to interim storage pending permanent disposal. Mercury wastes, once defined, will be subject to permanent disposal.

Export bans and domestic restrictions

For NGOs the challenge is to persuade their national government that mercury should not only be recovered from used products, medical equipment, industrial processes, wastes and contaminated sites but should also be prohibited from re-entering the supply chain. Activities to implement an export ban can be very valuable in reducing global supply of mercury. This will help prevent mercury from entering the market where it is likely to emerge some time later in highly polluting practices such as ASGM. While an export ban does not prevent recovered mercury from re-use for allowed purposes under the mercury treaty in a domestic setting, it does help prevent the global proliferation of mercury pollution.

Domestic restrictions on mercury trade may assist to reduce mercury pollution at a national level but lose effectiveness at a global level if export of elemental mercury is still permitted as the problem can be transferred elsewhere. The best possible outcome that can be achieved is export and import bans combined with domestic restrictions on mercury trade. However, governments need to be prepared for the reality of surplus stocks of elemental mercury arising and this is where NGOs can provide guidance in the criteria required to establish and operate environmentally sound and secure storage facilities.

12. CONCLUSION

It has been known for decades that mercury pollution causes serious harm to human health and the environment. Until recently, governments have resisted many of the control measures needed to minimize mercury pollution. This is now changing.

Growing public concern and an expanded scientific understanding of the harm caused by local, national and global mercury pollution has driven many governments to start taking meaningful action to control mercury atmospheric emissions and other mercury releases into the environment. The decision by governments to agree to a global mercury treaty makes it easier and very relevant for NGOs and others to initiate actions that address local, national, regional and global mercury issues and concerns. This is true in countries where mercury issues are already well established as part of the national environmental and political agenda, and it is increasingly true in countries and regions where concerns about mercury pollution are now just emerging.

This creates both an opportunity and an obligation for NGOs and other civil society organizations with missions relating to public health or environmental protection. It also creates opportunities and obligations for organizations that represent impacted constituencies such as people who eat fish as an important component of their diet, communities near mercury-polluting facilities, workers who are subject to mercury exposures and many others. Taking action on mercury-related issues can be highly successful in this present political climate and can have a big impact. Finally, now the mercury treaty has been signed by over 90 countries, and while national governments consider its ratification and then its implementation, national public awareness about mercury pollution will greatly influence how they decide to act.

Because of the global nature of mercury pollution, a global movement of NGOs and other organization's of civil society working together for solutions is essential. The International POPs Elimination Network is committed to building and strengthening this movement.

ANNEX 1 ARTICLES OF THE MINAMATA CONVENTION: AN IPEN SUMMARY AND ANALYSIS

The following analysis of the Articles of the mercury treaty have been included as an annex to the main body of this guide to provide additional context about the requirements that signatories to the treaty must fulfill. Some of these articles have an important relationship with key aspects of the treaty including exemptions, time limits, definitions, capacity building, technology transfer and monitoring. Articles of the mercury treaty that relate directly to mercury pollution issues have also been included in the body of this booklet in those sections most closely related to the pollution issue (e.g. Article 3 Mercury Supply sources and Trade is discussed in Section 7.5 The Need to Reduce Mercury Supply)

While those articles of the mercury treaty that relate directly to mercury pollution have been included in the preceding chapters of this guide for the convenience of the reader, it is important to consider them in context with the articles listed below to appreciate the full range of obligations of Parties to the Convention.

Treaty Preamble

- The preamble notes health concerns especially in vulnerable populations and concern for future generations.
- It notes the "particular vulnerabilities of Arctic ecosystems and indigenous communities" due to biomagnification of mercury in the food chain and contamination of traditional foods.
- It mentions Minamata disease "and the need to ensure proper management of mercury and the prevention of such events in the future."
- It notes that nothing in the treaty "prevents a Party from taking additional domestic measures consistent with the provisions of this Convention in an effort to protect human health and the environment from exposure to mercury."
- The word precaution and the polluter pays principle do not appear. Instead, they are lumped in with "reaffirmation" of the Rio Principles. In contrast the Stockholm Convention says, "precaution underlies the concerns of all the Parties and is embedded within this Convention…"

Article 1 Objective

- The objective of this Convention is to protect human health and the environment from anthropogenic releases of mercury and mercury compounds.

Article 2 Definitions

(a) "Artisanal and small-scale gold mining" means gold mining conducted by individual miners or small enterprises with limited capital investment and production.

(b) "Best available techniques" means those techniques that are the most effective to prevent and, where that is not practicable, to reduce emissions and releases of mercury to air, water, and land and the impact of such emissions and releases on the environment as a whole, taking into account economic and technical considerations for a given Party or a given facility within the territory of that Party. “Best” means most effective in achieving a high general level of protection of the environment as a whole.

“Available” techniques means, in respect of a given Party and a given facility within the territory of that Party, those techniques developed on a scale that allows implementation in a relevant industrial sector under economically and technically viable conditions, taking into consideration the costs and benefits, whether or not those techniques are used or developed within the territory of that Party, provided that they are accessible to the operator of the facility as determined by that Party.

“Techniques” means technologies used, operational practices and the ways in which installations are designed, built, maintained, operated, and decommissioned.

(c) “Best environmental practices” means the application of the most appropriate combination of environmental control measures and strategies.

(d) “Mercury” means elemental mercury (Hg (0), CAS No. 7439-97-6).

(e) “Mercury compound” means any substance consisting of atoms of mercury and one or more atoms of other chemical elements that can be separated into different components only by chemical reactions.

(f) “Mercury-added product” means a product or product component that contains mercury or a mercury compound that was intentionally added.

(g) “Party” means a State or regional economic integration organization that has consented to be bound by this Convention and for which the Convention is in force.

(h) “Parties present and voting” means Parties present and casting an affirmative or negative vote at a meeting of the Parties.

(i) “Primary mercury mining” means mining in which the principal material sought is mercury.

(j) “Regional economic integration organization” means an organization constituted by sovereign States of a given region to which its member States have transferred competence in respect of matters governed by this Convention and which has been duly authorized, in accordance with its internal procedures, to sign, ratify, accept, approve, or accede to this Convention.

(k) "Use allowed" means any use by a Party of mercury or mercury compounds consistent with this Convention, including, but not limited to, uses consistent with Articles 3, 4, 5, 6, and 7. Note: this proposal makes artisanal small scale gold mining (ASGM) an allowed use under the Convention without additional warning or caution and approves the use of a toxic substance in a sector that is illegal in most countries. Fortunately, some countries have already banned or prohibited the use of mercury in mining/ASGM.

Article 3 Mercury supply sources and trade

- New primary mining is banned as of the entry into force by a government. However, a government may permit new mercury mines before then; and if a government postpones ratification, then it has a longer window of time.
- Pre-existing primary mercury mining is banned after 15 years as of date of entry into force for a government. If a government postpones ratification, then it can mine mercury from pre-existing mines for a longer period.
- Mercury from primary mining after ratification can only be used for making permitted products or used in permitted processes (such as VCM, etc., described below in Articles 4 and 5), or disposed according to treaty requirements. This implies that mercury from primary mining shall not be available for use in ASGM once a country ratifies the treaty.
- Identifying stocks of mercury greater than 50 metric tons is optional but countries "shall endeavor" to do it. This paragraph is actually linked to Article 10 regarding Interim Storage. Note: this paragraph could also be relevant for identifying ASGM activities within a country since stocks greater than 10 metric tons may signal ASGM activity. Parties could make identification of stocks more comprehensive and useful by including information about the annual capacity of the interim storage/stocks facility, explaining what the stocks are for and plans for them in the future.
- Since ASGM is an allowed use, trade of mercury for ASGM is allowed. However, countries that have already prohibited the use of mercury in mining and ASGM should strengthen their commitment to prohibiting trade of mercury for this use as well.
- Countries are required to "take measures" to ensure that when a chlor-alkali plant closes, the excess mercury is disposed of according to treaty requirements and not subject to recovery, recycling, reclamation, direct re-use, or alternative uses. This is good because it should prevent this mercury from

re-entering the market. However, good mechanisms are still needed to ensure this. Note: countries are to take measures to ensure that these wastes are treated in an environmentally sound manner according to Article 11 and future guidelines developed by the COP and added to the treaty.

- Trade of mercury, including recycled mercury from non-ferrous metal smelting and mercury-containing products, is permitted if it is for an "allowed use" under the treaty.
- The treaty contains a "prior informed consent" procedure for mercury trade that requires the importing country to provide the exporting party with its written consent to the import and then to ensure that the mercury is only used for the allowed uses under the treaty or for interim storage.
- A public register maintained by the Secretariat will contain consent notifications.
- If a non-party exports mercury to a party, it has to certify that it is not from prohibited sources.
- The article does not apply to trade of "naturally occurring trace quantities of mercury or mercury compounds" in mining ores, coal, or "unintentional trace quantities" in chemical products or any mercury-containing product.
- The COP can later evaluate if trade in specific mercury compounds is undermining the objective of the treaty and decide if a specific mercury compound should be added to the article.
- Each Party has to report to the Secretariat (Article 21), showing that it has complied with the requirements of this article.

Article 4 Mercury-added products

(discussed in section 8)

- Product prohibition occurs by "taking appropriate measures" to "not allow" the manufacture, import, or export of new mercury-containing products *Note:* the sale of existing stocks is permitted.
- The treaty uses a so-called 'positive list' approach. This means that the products to be phased out are listed in the treaty; others are presumably not addressed by the treaty.
- Parties are to discourage the manufacture and distribution in commerce of new mercury-added products before the treaty enters into force for them unless they find that a risk and benefits analysis shows environmental or human health benefits. These 'loophole' products are to be reported to the Secretariat, which will make the information publicly available.

- There is a list of products whose manufacture, import and export are scheduled to be phased out by 2020. However (see Article 6), countries can apply for a five-year exemption to the phase-out date and this can be renewed for a total of 10 years, making the effective phase-out date for a product, 2030.
- Products whose manufacture, import and export are to be phased out by 2020 include batteries (except for button zinc silver oxide batteries with a mercury content < 2 percent, button zinc air batteries with a mercury content < 2 percent); most switches and relays; CFL bulbs equal to or less than 30 watts containing more than 5 mg mercury per bulb (an unusually high amount); linear fluorescent bulbs - triband lamps less than 60 watts and containing greater than 5 mg mercury and halophosphate lamps less than 40 watts and containing greater than 10 mg mercury; high pressure mercury vapor lamps; mercury in a variety of cold cathode fluorescent lamps and external electrode fluorescent lamps; cosmetics including skin lightening products with mercury above 1 ppm except mascara and other eye area cosmetics (because the treaty claims that no effective safe substitute alternatives are available); pesticides, biocides, and topic antiseptics; and non-electronic devices such as barometers, hygrometers, manometers, thermometers, and sphygmomanometers (to measure blood pressure).
- A product to be "phased down" is dental amalgam and countries are supposed to pick two measures from a list of nine possibilities taking into account "the Party's domestic circumstances and relevant international guidance." The possible actions include picking two items from a list that includes establishing prevention programs to minimize the need for fillings, promoting use of cost-effective and clinically effective mercury-free alternatives, discouraging insurance programs that favor mercury amalgam over mercury-free alternatives, and restricting the use of amalgam to its encapsulated form.
- Products excluded from the treaty include products essential for civil protection and military uses; products for research and calibration of instruments for use as a reference standard; switches and relays, CCFL and EEFL for electronic displays, and measuring devices, if no mercury-free alternative available; products used in traditional or religious practices; vaccines containing thiomersal as preservatives (also known as thimerosal); and mercury in mascara and other eye area cosmetics (as noted above).
  Note: some products listed for prohibition in previous drafts such as paints were excluded during the negotiation process.
- Secretariat will receive information from Parties on mercury-added products and make the information publicly available along with any other relevant information.

- Parties can propose additional products to be phased-out including information on technical and economic feasibility and environmental and health risks and benefits.
- The list of prohibited products will be reviewed by the COP five years after the treaty enters into force; this could be approximately 2023.

Article 5 Manufacturing processes in which mercury or mercury compounds are used

(discussed in section 9.4)

- Phased-out processes using mercury include chlor-alkali production (2025) and acetaldehyde production using mercury or mercury compounds as a catalyst (2018).
- Note: Article 5 specifies that countries can apply for a five-year exemption to the phase-out date under Article 6, renewable for a total of 10 years, making the effective phase-out dates for the processes above 2035 and 2028 respectively.
- Restricted processes allow continued use of mercury with no current phase-out date. These include the production of vinyl chloride monomer (VCM), sodium or potassium methylate or ethylate, and polyurethane. Note: VCM production does not appear in UNEP air emission inventories due to lack of data. VCM production using coal and a mercury catalyst is unique to China and a potentially enormous source of mercury releases.
- For VCM and sodium or potassium methylate or ethylate production, Parties are to reduce mercury per unit production by 50 percent in 2020 compared to 2010 use. Note: since this is calculated on a "per facility" basis, total mercury use and release can rise as new facilities are built.
- Additional measures for VCM include promoting measures to reduce use of mercury from primary mining, supporting research and development of mercury-free catalysts and processes, and prohibiting the use of mercury within five years after the COP establishes that mercury-free catalysts based on existing processes are technically and economically feasible.
- For sodium or potassium methylate or ethylate, Parties have to aim to phase out this use as fast as possible and within 10 years of entry into force of the treaty, prohibit the use of fresh mercury from primary mining, support research and development of mercury-free catalysts and processes, and prohibit the use of mercury within five years after the COP establishes that mercury-free catalysts based on existing processes are technically and economically feasible.

- For polyurethane, Parties are to aim "at the phase out of this use as fast as possible, within 10 years of the entry into force of the Convention." However, the treaty exempts this process from paragraph 6, which prohibits Parties from using mercury in a facility that did not exist prior to the date of entry into force. This implies that new polyurethane production facilities using mercury can be operated after the treaty comes into force for a Party.
- Parties have to "take measures" to control emissions and releases as outlined in Articles 8 and 9, and report to the COP on implementation, and try to identify facilities that use mercury for the processes in Annex B and submit information on estimated amounts of mercury used by them to the Secretariat three years after entry into force for the country.
- Exempted processes not covered by the article include processes using mercury-added products, processes for manufacturing mercury-added products, or processes that process mercury-containing waste.
- Parties are not allowed to permit the use of mercury in new chlor-alkali plants and acetaldehyde production facilities after the treaty comes into force (estimated to be approximately 2018).
- The regulated processes are the ones listed above (and in Annex B). However, Parties are supposed to "discourage" the development of new processes using mercury. Note: Parties can allow these mercury-using processes if the country can demonstrate to the COP that it "provides significant environmental and health benefits and that there are no technically and economically feasible mercury-free alternatives available providing such benefits."
- Parties can propose additional processes to be phased-out, including information on technical and economic feasibility as well as environmental and health risks and benefits.
- The list of prohibited and restricted processes will be reviewed by the Conference of the Parties five years after the treaty enters into force; this could be approximately 2023.

Article 6 Exemptions available to a Party upon request

- Parties can register for a five-year exemption from the phase-out dates for products or processes (listed in Annexes A and B) when they become a Party or when new products or processes are added to the treaty. Parties do need to explain why they need the exemption.
- Like the Stockholm Convention, the mercury treaty will establish a publicly available register of exemptions that will include a list of which countries have requested which exemptions and the expiry date of each one.

- The five-year exemption period can be extended for another five years if the COP agrees to a request from a Party. To make this decision, the COP is supposed to take into account a report from the requesting Party justifying the extra time, information on availability of alternatives, circumstances of developing and transition countries, and activities to provide environmentally sound storage and disposal. An exemption can only be extended once per product per phase-out date.
- No exemptions are permitted after the 10-year period has expired from the phase-out date listed in Annex A or B.

Article 7 Artisanal and small-scale gold mining (ASGM)

(discussed in section 9.4)

- The objective is to "take steps to reduce, and where feasible eliminate, the use of mercury and mercury compounds in, and the releases to the environment of mercury from, such mining and processing." The ASGM activity is defined as, "mining and processing in which mercury amalgamation is used to extract gold from ore."
- It applies to countries that admit that ASGM is "more than insignificant."
- ASGM is an allowed use under the treaty. This qualifies it for mercury trade without any specific import limits – either in quantities or in time. Note: in some countries (or parts of countries), such as Indonesia, Malaysia, and the Philippines, the use of mercury in ASGM and mining is already prohibited. These and other countries that have already prohibited the use of mercury in mining and ASGM should strengthen their commitment to prohibiting trade of mercury for this use as well.
- According to the trade provisions (Article 3) mercury from primary mercury mines and chlor-alkali facilities cannot be used for ASGM after the treaty enters into force. Monitoring measures and public participation can help insure that this provision is enforced.
- If the country notifies the Secretariat that Article 7 applies to it (by indicating that the activity is "more than insignificant"), then it is required to develop a national action plan (NAP) and submit it to the Secretariat by three years after entry into force with a review every three years.
- Plan requirements include a national objective and reduction target and actions to eliminate the following worst practices: whole ore amalgamation; open burning of amalgam or processed amalgam; amalgam burning in residential areas; and cyanide leaching in sediment, ore, or tailings to which mer-

cury had been added without first removing the mercury. Countries should work to establish a sunset date or reduction target in their national objectives.

- Other plan components include steps to facilitate formalization or regulation of ASGM; baseline estimates of amounts of mercury used in the practice; strategies for promoting the reduction of emissions and releases of and exposure to mercury; strategies for managing trade and preventing the diversion of mercury into ASGM; strategies for involving stakeholders in the implementation and continuing development of the national action plan; a public health strategy on the exposure of ASGM miners and their communities to mercury, including the gathering of health data, training for health-care workers, and awareness-raising through health facilities; strategies to prevent the exposure of vulnerable populations, particularly children and women of child-bearing age, especially pregnant women, to mercury used in artisanal and small-scale gold mining; strategies for providing information to ASGM miners and affected communities; and a schedule for implementation of the national action plan. Note: while cleaning up the mercury-contaminated sites is not included in the treaty text, the proposed action plan can include this important component of addressing mercury pollution.
- Optional activities include the "use of existing information exchange mechanisms to promote knowledge, best environmental practices and alternative technologies that are environmentally, technically, socially and economically viable."
- Although mercury use is allowed for the ASGM sector, there is no phase-out date for ASGM in Article 7. In addition, ASGM is not covered by Article 5 (mercury added-processes). However, countries can establish phase-out dates in their national action plans and address ASGM in other articles as described.

Article 8 Emissions (air)

(discussed in section 10)

- The objective is "controlling and where feasible reducing emissions of mercury and mercury compounds..." Note: emissions mean air emissions from point sources in Annex D and country discretion decides what is feasible.
- For existing sources, the objective of the article is "for the measures applied by a party to achieve reasonable progress in reducing emissions over time."
- Air emission sources included in the treaty are coal-fired power plants and industrial boilers; smelting and roasting processes used in production of non-

ferrous metals (only lead, zinc, copper, and industrial gold); waste incineration; and cement clinker production facilities.

- Emission sources that were deleted from the treaty during negotiation were oil and gas; facilities in which mercury-added products are manufactured; facilities that use mercury in manufacturing processes; iron and steel manufacturing including secondary steel; and open burning.
- Negotiators at INC5 did not find it necessary to set threshold limit values for emission sources, leaving the possibility to develop emission limit values at the discretion of the Parties.
- Preparing a NAP to control emissions is optional. If one is created, it is submitted to the COP within four years of entry into force for the Party.
- New sources have stronger control measures than existing sources.
- For new sources BAT/BEP is required to "control and where feasible reduce" emissions and BAT/BEP is to be implemented no later than five years after the treaty enters into force for that Party. Emission limit values can substitute for BAT if they are consistent with its application.
- If a government postpones ratification, then it has a longer window of time to construct new sources without requiring BAT/BEP.
- BAT/BEP Guidance will be adopted at COP1. Presumably an expert group will develop the guidance before then during intercessional periods between future INCs.
- A new source can be either new construction one year after entry into force for the country or a substantially modified facility within category sources listed in Annex D. The language specifies that to "convert" an existing source to a new source through modification there must be a "significant increase in mercury emissions, excluding any change in emissions resulting from by-product recovery." The Party gets to choose whether any existing source is subject to the more stringent requirements of new sources.
- Measures on existing sources are to be implemented as soon as practicable but no later than 10 years after the treaty enters into force for that Party.
- Measures on existing sources can take into account "national circumstances, and the economic and technical feasibility, and affordability of the measures."
- There is no requirement for an existing facility to apply BAT/BEP. Instead, countries can choose one item from a menu that includes a quantified goal (could be any goal), emission limit values, BAT/BEP, multi-pollutant control strategy, and alternative measures.

- All reductions are taken on a "per facility" basis, so an increased number of facilities will increase total mercury emissions.
- Parties have to establish an inventory of emissions from relevant sources (Annex D) as soon as possible and not later than five years after entry into force for the country.
- The COP has to adopt, as soon as possible, guidance on methods to prepare the inventories and criteria that Parties can develop to identify sources within a category.
- Parties have to report on their actions under this article according to the requirements in Article 21.

Article 9 Releases (land and water)

(discussed in section 10)

- The objective is "controlling and where feasible reducing emissions of mercury." Note: releases means mercury releases to land and water from point sources that are not covered in other provisions of the treaty. Country discretion decides what is feasible.
- Sources included in the treaty are defined by countries. During the negotiations, Annex G in the draft text contained a list of possible sources but negotiators deleted the annex at INC5 so that there are no guidelines for countries to know what sources might release mercury to land and water. Annex G contained the following sources: facilities in which mercury-added products are manufactured; facilities that use mercury or mercury compounds in the manufacturing processes listed in Annex D; and facilities in which mercury is produced as a by-product of non-ferrous metals mining and smelting.
- The article controls "relevant sources" – those are point sources identified by countries that release "significant" amounts of mercury.
- Preparing a NAP to control emissions is optional. If one is created, it is submitted to the COP within four years of entry into force for the Party.
- As for control measures, Parties are to apply one of the following "as appropriate": release limit values, BAT/BEP, multi-pollutant control strategy, or alternative measures.
- Parties are to identify sources of mercury releases to land and water no later than three years after entry into force for the country, and on a regular basis thereafter.
- Parties are to establish an inventory of releases from relevant sources as soon as possible and no later than five years after entry into force for the country.

- COP "as soon as practicable" is to develop guidance on BAT/BEP and a method for preparing inventories of releases.
- Parties have to report on their actions under this article according to the requirements in Article 21.

Article 10 Environmentally sound interim storage of mercury, other than waste mercury

(discussed in section 11.4)

- Interim storage of mercury can only be for a use allowed under the treaty. The interim storage has a similar function as the storage of mercury stocks.
- Parties must "take measures" to ensure that interim storage of mercury is carried out in an environmentally sound manner and ensure that these facilities do not become mercury hotspots.
- The COP is to adopt guidelines on storage taking Basel Convention Guidelines into account, but the treaty does not specify when these guidelines have to appear. These guidelines should address various types of interim storage, including national or regional interim storage.
- The guidelines on storage may be added as an annex to the treaty.

Article 11 Mercury wastes

(discussed in section 11.2)

- The treaty applies the Basel definitions of waste to the mercury treaty: wastes consisting of or containing mercury compounds or contaminated with mercury or mercury compounds.
- The COP in collaboration with the Basel Convention will decide the relevant thresholds for determining the relevant quantities of mercury in wastes that make it hazardous.
- The treaty specifically excludes tailings from mining (except primary mercury mining) unless the wastes contain mercury above the thresholds defined by the COP. This covers tailings containing mercury from all types of mining operations.
- Parties are to "take measures" so that mercury waste is managed in an environmentally sound manner according to Basel Convention guidelines and future guidelines that will be added to the treaty.
- No corporate or polluter responsibility is identified in the article, however national governments may wish to make use of these economic instruments.

- In developing waste guidelines, the COP must take national waste management programs and regulations into account.
- Mercury waste can only be recovered, recycled, reclaimed, or directly used for a use allowed under the treaty. Note: mercury from decommissioned chlor-alkali plants is regulated separately under Article 3 (Supply and Trade).
- Basel Convention Parties are not permitted to transport waste across international boundaries except for environmentally sound disposal.
- Non-Basel Parties are to take into account relevant international rules, standards and guidelines.

Article 12 Contaminated sites

(discussed in section 11)

- Parties "shall endeavor" to take action on contaminated sites.
- Possible actions include developing strategies for identifying and assessing contaminated sites and actions to reduce risks, incorporating an assessment of risks to human health and the environment.
- The COP is to develop guidance on managing contaminated sites but the treaty does not provide a deadline for the guidance.
- The guidance on managing contaminated sites includes topics such as site identification and characterization; engaging the public; human health and environmental risk assessments; options for managing the risks posed by contaminated sites; evaluation of benefits and costs; and validation of outcomes.

Article 13 Financial resources and mechanisms

- The article confirms that the overall effectiveness of treaty implementation by developing countries is related to effective implementation of the financial mechanism.
- The article commits each Party to allocating resources for treaty implementation taking into account national policies, priorities, plans, and programs.
- A variety of funding sources are encouraged, including multilateral, regional, and bilateral sources.
- "The Mechanism shall encourage the provision of resources from other sources, including the private sector, and shall see to leverage such resources for the activities it supports."

- Actions on funding must take full account of the specific needs and special circumstances of Small Island Developing States and Least Developed Countries.
- Characteristics of the mechanism to support implementation of the treaty by developing and transition countries include the provision of "adequate, predictable, and timely financial resources."
- The financial mechanism includes a Global Environment Facility (GEF) trust fund and a "special international program" that will provide capacity building and technical assistance.
- Obligations of the GEF trust fund include providing "new, predictable, adequate and timely financial resources to meet costs in support of implementation of the Convention."
- GEF trust fund will operate under guidance of the COP and be accountable to it.
- GEF trust fund will provide resources to meet agreed incremental costs of global environmental benefits and agreed full costs of some enabling activities.
- GEF takes into account the potential mercury reductions of a proposed activity relative to its costs.
- COP guidance to the GEF trust fund includes strategies, policies, priorities, eligibility, and an indicative list of categories of activities that could receive support from the GEF.
- The international program will be operated under the guidance of the COP and accountable to it.
- The international program will be hosted at an existing entity decided by COP1.
- The international program will be funded on a voluntary basis.
- COP will review the financial mechanism no later than COP3 and afterwards on a regular basis.

Article 14 Capacity-building, technical assistance, and technology transfer

- The article obligates Parties to "cooperate" to provide timely and appropriate capacity-building and technical assistance "within their respective capabilities."
- Least Developed Countries and Small Island Developing States are highlighted as recipients of tech transfer.

- A variety of arrangements are mentioned as possibilities: regional, sub regional, and national.
- Synergies with other agreements are encouraged.
- Developed country Parties, and others within their capabilities, are obligated to promote and facilitate development, transfer and diffusion of and access to "up-to-date environmentally sound alternative technologies." The private sector and other stakeholders are supposed to support them in this effort.
- By COP2, and regularly thereafter, governments will evaluate the success of this article by considering progress on alternative technologies and initiatives, needs of Parties, and challenges in technology transfer. The COP will make recommendations on how capacity building, technical assistance and technology transfer could be further enhanced.

Article 15 Implementation and compliance committee

- The objective of the committee is to "promote implementation of, and review compliance with, all provisions of the Convention."
- In this work, the committee is to examine both individual and systemic issues of implementation and compliance and make recommendations to the COP.
- The committee is obligated to be "facilitative in nature and shall pay particular attention to the respective national capabilities and circumstances of Parties."
- The committee will be a subsidiary body of the COP.
- The committee has 15 members (three from each UN region) elected at COP1 and thereafter according to the upcoming Rules of Procedure.
- The COP can adopt further terms of reference for the committee.
- Members must have "competence in a field relevant to this Convention and reflect an appropriate balance of expertise."
- In its operation, the committee can consider written submissions from a Party about its own compliance; national reports; and requests from the COP.
- The committee will make every effort to operate by consensus. If that fails then it can adopt recommendations by a three-fourths majority vote of the members present and voting based on a quorum of two-thirds of its members.

Article 16 Health aspects

(discussed in section 5)

- The treaty text states that "Parties are encouraged to...undertake health related activities." Optional activities include:
- Strategies and programs to identify and protect populations at risk.
- Development and implementation of science-based educational and preventive programs on occupational exposure to mercury.
- Promoting appropriate health-care services for prevention, treatment, and care of populations affected by mercury exposure.
- Establishing and strengthening institutional and health professional capacities for prevention, diagnosis, treatment, and monitoring of health risks related to mercury exposure.
- The COP should consult with WHO, ILO, and other relevant intergovernmental organizations as appropriate.
- The COP should promote cooperation and exchange of information with WHO, ILO, and other relevant intergovernmental organizations.

Article 17 Information exchange

- The article obligates parties to facilitate the exchange of various types of information including scientific, technical, economic, legal, ecotoxicological, and safety information; information on reduction or elimination of production, use, trade, emissions, and releases of mercury; information on technically and economically viable alternatives to mercury-added products, manufacturing processes using mercury, and activities and processes that release mercury; information on alternatives, including health and environmental risks, and economic and social costs and benefits of such alternatives; and epidemiological information.
- Information can be exchanged through the Secretariat, through other organizations, or directly.
- The Secretariat is obligated to facilitate cooperation in the exchange of information.
- Parties have to establish a national focal point for the exchange of information.
- Delegates agreed, "Information on the health and safety of humans and the environment shall not be regarded as confidential."

- Other types of information involving the treaty that is exchanged "shall protect any confidential information as mutually agreed."

Article 18 Public information, awareness and education

- This article obligates Parties to promote and facilitate providing information to the public "within its capabilities."
- Information includes health and environmental effects of mercury, alternatives to mercury, results of research and monitoring activities, activities to meet obligations under the treaty and the activities referred to in Articles 17 and 19.
- Parties are also supposed to promote and facilitate "education, training and public awareness related to the effects of exposure to mercury and mercury compounds on human health and the environment in collaboration with relevant intergovernmental and nongovernmental organizations and vulnerable populations, as appropriate."
- Parties are supposed to use existing mechanisms or give consideration to the development of mechanisms such as PRTR, "or the collection and dissemination of information on estimates of its annual quantities of mercury and mercury compounds that are released or disposed of through human activities."

Article 19 Research, development and monitoring

- This article is voluntary and contains a series of optional activities. The treaty text state that "Parties shall endeavor to cooperate to develop and improve, taking into account their respective circumstances and capabilities...."
- Optional activities to develop and improve include inventories, modeling, impact assessments on human health and the environment, methods development, information on environmental fate and transport, information on commerce and trade, information on alternatives, and information on BAT/ BEP.
- Parties are encouraged to use existing monitoring networks and research programs if appropriate.

Article 20 Implementation plans

- Developing and executing an implementation plan is optional.
- If a plan is developed, it should follow an initial assessment and be transmitted to the Secretariat.
- In developing an implementation plan, Parties should "consult national stakeholders to facilitate the development, implementation, review and updating of their implementation plans."

- Parties can also coordinate on regional plans to facilitate treaty implementation.
- NGOs can participate in the consultation with national stakeholders in developing, implementing, reviewing, and updating the National Implementation plan (NIP).

Article 21 Reporting

- Each Party must report to the COP through the Secretariat on the measures that it has taken to implement the treaty and on the effectiveness of its measures in meeting the treaty's objectives.
- COP1 decides the timing and format of the reporting, taking into account coordinating reporting on the mercury treaty with reporting required by other relevant chemicals and wastes conventions.

Article 22 Effectiveness evaluation

- The COP evaluates the effectiveness of the treaty no later than six years after it enters into force and periodically thereafter.
- COP1 will initiate arrangements for providing comparable monitoring data on the "presence and movement of mercury and mercury compounds in the environment as well as trends in levels of mercury and mercury compounds observed in biotic media and vulnerable populations."
- Evaluation will be conducted using available scientific, environmental, technical, financial, and economic information including reports and monitoring information provided to the COP, national reports, information and recommendations from the implementation and compliance committee, and other reports on the operation of the financial and technical assistance mechanism.

Article 23 Conference of the Parties

- COP1 will be convened by the Executive Director of UNEP no later than one year after the treaty enters into force.
- The COP will meet regularly in a schedule that it decides.
- The COP can have extraordinary meetings as decided by the COP or at written request of a Party if at least one-third of the Parties support the proposal within six months.
- COP1 will adopt Rules of Procedure by consensus along with financial rules for itself and provisions governing the functioning of the secretariat.

Article 24 Secretariat

- Secretariat functions performed by the Executive Director of UNEP unless the COP decides by the three-fourths vote to change the secretariat to a different international organization.
- Secretariat functions include making arrangement for meetings of the COP and subsidiary bodies; facilitate assistance to Parties, especially those from developing and transition countries; coordinate with Secretariats of relevant international bodies such as chemicals and waste conventions; assist in exchange of information; prepare periodic reports; and undertake other duties assigned to it by the COP.

Article 25 Settlement of disputes

- Parties are obligated to settle any dispute regarding interpretation or application of the treaty through negotiation or peaceful means.
- When ratifying, accepting, approving, or acceding to this Convention, any Party may give written notice that it recognizes one or both of the following means of dispute settlement: Arbitration in accordance with the procedure set out in Part I of Annex E or submission of the dispute to the International Court of Justice.
- If the parties have not accepted a specific means of settlement described above and if they have not settled the dispute within 12 months, then the dispute will be submitted to a conciliation commission at the request of any party to the dispute and be governed under Annex E.

Article 26 Amendments to the Convention

- Any Party can propose an amendment.
- Amendments are adopted at a meeting of the COP by consensus.
- If consensus cannot be reached, then, as a last resort, the amendment can be adopted by a three-fourths majority vote of the parties present and voting.
- The amendment enters into force 90 days after three-fourths of the Parties signal agreement with deposits of instruments of ratification, acceptance, or approval. After that, it enters into force for a party 90 days after it signals agreement.

Article 27 Adoption and amendment of annexes

- Annexes are an official part of the treaty.

- Additional annexes can only concern procedural, scientific, technical, or administrative matters.
- Annexes are proposed according to Article 26.
- After one year, the annex enters into force for most Parties.
- If a Party cannot accept an annex, it has to notify the Depositary within one year. A Party can reverse this decision.
- Amendments are handled like annexes including the opt-in procedure described below in Article 30.

Article 28 Right to vote

- Each party has one vote. The EU gets the number of votes equal to the number of its members (currently 27). The EU cannot vote if any of its member states decides to vote on its own behalf and vice versa.

Article 29 Signature

- The mercury treaty is open for signature at Kumamoto, Japan, from 10 October 2013 for one year.
  Note: signature means that a country gives preliminary and general endorsement of the treaty. Signature is not legally binding and does not commit the country to proceed to ratification. However, countries that sign the treaty should not take actions to defeat the treaty or undermine it in any way.

Article 30 Ratification, acceptance, approval, or accession

- Ratification creates legally binding obligations and often results in amending national legislation to comply with treaty provisions.
- The treaty is open for ratification from the day the convention is closed for signature.
- When they ratify, countries are encouraged to provide information to the Secretariat on their measures to implement the treaty.
- A country can declare in its instrument of ratification that any amendment only enters into force for it when it deposits its instrument of ratification for it. As a result, a new amendment is not automatically in force for countries that make this declaration unless they signal in writing that they accept the amendment. This is the "opt-in" procedure that is also used by 20 countries of the Stockholm Convention.

Article 31 Entry into force

- The convention enters into force 90 days after the 50th country ratifies the treaty.
- For countries that ratify after the 50th country, the treaty enters into force for them 90 days after depositing their ratification.

Article 32 Reservations

- No reservations may be made to the convention.
- Note: a "reservation" is a statement by a country when ratifying that excludes or modifies certain parts of the treaty as it applies to them. The Stockholm Convention also does not permit reservations.

Article 33 Withdrawal

- Three years (or later) after the treaty enters into force for a government, it can withdraw from the treaty by giving written notification.
- The withdrawal enters into force one year after official notice is given or later if specified by the country.

Article 34 Depositary

- UN Secretary-General is the depositary of the convention. A depositary is an institution to which a multilateral treaty is entrusted and its functions are outlined in Article 77 of the Vienna Convention on the Law of Treaties. This includes having custody of the original text, preparing further text of the treaty, receiving signatories, informing governments about matters related to the treaty, and notifying when the treaty enters into force.

Article 35 Authentic texts

- The text of the convention is equally authoritative in each of the six UN languages: Arabic, Chinese, English, French, Russian, and Spanish

ANNEX 2 THE IPEN MINAMATA DECLARATION ON TOXIC METALS

The IPEN Minamata Declaration on Toxic Metals

Statement of IPEN Participating Organizations agreed in Minamata, Japan on the occasion of the Conference of Plenipotentiaries on the mercury treaty in October 2013

The Participating Organizations of IPEN hereby stand in solidarity with Minamata victims' groups in agreeing that Minamata is not just a name, a place or a disease. It is more. It is also pain, corporate irresponsibility, loss, and discrimination. Minamata is about people and community. It is about their struggle to survive, and their determination to live. This is the real Minamata.

As IPEN Participating Organizations, we declare our firm resolve and our expanded commitment to work toward ensuring that toxic metals such as mercury, lead and cadmium no longer pollute our local and global environments, and no longer contaminate our communities, our food, our bodies, or the bodies of our children and future generations.

Furthermore,

We welcome the global consensus that mercury pollution is a serious threat to human health and the environment and that action is needed to minimize and eliminate mercury emissions and releases in order to reduce this threat;

We stress that mercury is a chemical of global concern owing to its long-range atmospheric transport, its persistence in the environment, its ability to bioaccumulate in ecosystems and the food chain, and its significant negative intergenerational effects on human health and the environment;

We highlight the health impacts of mercury on vulnerable populations, such as women, children, and, through them, future generations especially in developing and transition countries;

We recognize the serious and long lasting injury to ecosystems and human health that mercury can cause in communities both near source locations, and also in distant regions;

We stress the particular vulnerabilities of Arctic ecosystems and Indigenous Peoples due to biomagnification of mercury and contamination of traditional foods;

We acknowledge the well-established scientific evidence of the harm caused by mercury in seafood, affecting many communities dependent on fish and seafood as their primary source of protein; and we note the special concerns about mercury accumulation in all living organisms, including humans;

We acknowledge and support the demands and struggles of workers, women and children, Indigenous Peoples, miners, fishers, Arctic communities, island and coastal dwellers, small-scale gold miners, the poor, and all other social groups that are affected by exposure to mercury. We call for solidarity and support to all impacted groups in the exercise of their right to a healthy environment, worker protection, right to know, fair compensation, medical treatment and environmental justice;

We emphasize the need for greater commitment to mandate action on artisanal small-scale gold mining to facilitate miners' access to effective and appropriate technologies that minimize or, where feasible, avoid the use of mercury, to stop the mercury trade and supply in ASGM areas, remediate contaminated sites and ensure their rehabilitation, and create programs to assist miners in securing alternative livelihoods;

We emphasize the need for rigorous control measures to reduce and eliminate mercury releases from large-scale mining operations, to protect air and water quality and prevent soil contamination;

We emphasize the need for rigorous control measures to reduce and eliminate mercury pollution from coal-fired power plants while promoting the use of renewable, safe, alternative energy sources;

We highlight the need for the environmentally sound management of mercury during interim and long term storage and disposal and for a low-mercury limit protective of human health;

We urge strengthening obligatory measures to address mercury releases to land and water and urge rigorous and rapid actions to identify, reduce, and eliminate these releases, including from contaminated sites;

We call attention to mercury releases from manufacturing processes including vinyl chloride monomer production, and call on the private sector to reduce and eliminate releases and take every measure to introduce mercury-free production methods;

We call upon governments to rapidly ratify the mercury treaty and rigorously implement its objectives and provisions so that total emissions and releases of mercury are reduced and eliminated;

We are determined to take ongoing action to highlight the damage caused by toxic metal pollution to human health and the environment and to foster international support for further national and global governance measures to reduce, and where possible eliminate, sources of toxic metal pollution such as mercury, lead and cadmium;

We note the need to reduce and eliminate exposure to toxic metals such as mercury, lead, cadmium, arsenic and others in the lifecycle of a variety of products including consumer, medical and dental products, pesticides, and others.

We call on the private sector to take responsibility to rigorously reduce use and releases of toxic metals and to take responsibility for cleanup and compensation;

We recognize and reaffirm the precautionary principle and principles of right to know, intergenerational equity, environmental justice, polluter pays, and liability and compensation.

ACKNOWLEDGEMENTS

IPEN would like to thank the hundreds of NGOs, CSOs, labor groups, and health groups around the world for their contributions to the IPEN Mercury-Free Campaign and the IPEN Toxic Metal Program. IPEN gratefully acknowledges the financial support provided by the governments of Sweden and Switzerland, the Swedish Society for Nature Conservation, SSNC and other donors, which made the production of this document possible. The views herein shall not necessarily be taken to reflect the official opinion of any of these institutions providing financial support.

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