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Item 5 of the provisional agenda*

Report on activities under the UNEP mercury programme

Awareness raising: a modular approach

1. The Chemicals Branch of the United Nations Environment Programme's Division of Technology, Industry and Economics (UNEP Chemicals) has developed a package of awareness-raising material designed to meet the need expressed by several countries for additional outreach materials. The package has been designed to address the information needs of Governments, industry and the general public and has been designed according to a modular approach in order to facilitate its use by these groups.

2. The draft awareness-raising material set out in the annex to the present note is available for comments and input from all stakeholders is welcomed. Comments should be submitted to UNEP Chemicals as soon as possible and not later than 31 December 2007. The material will be revised taking into account the comments received and will be reissued in March 2008. Governments and other stakeholders are encouraged to use the materials in their awareness-raising programmes on mercury and to provide comments to UNEP Chemicals on their experience in doing so. The document will be revised subsequently on the basis of those findings and reissued as necessary.

* UNEP(DTIE)/Hg/OEWG.1/1.

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Annex

Cover Page

Mercury

A priority for action

Important community messages

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NOTE TO DESIGNER: We want to include a disclaimer for each of the modules. We seek your advice on where.

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NOTE: A CD with presentations for use will be tucked in the back of the final package.

NOTE TO DESIGNER:
This is intended as one loose leaf sheet to tuck in the front of the package. It would be two-sided.

What is this publication?
The publication is intended to raise awareness amongst stakeholders of the effects of mercury on human health, wildlife and the environment and on relevant strategies to manage and control mercury.

It is designed for the use of government officials, community leaders, and/or workers to provide information and raise awareness about mercury and the associated environment and health risks. It is intended to contribute in building public support and the capacity to take preventive actions.

The document can be used in a number of ways:

- for reference,
- to train staff,
- to present or hand out as copies directly from the toolkit,
- to develop materials specific to your community.

How is it laid out?
The package begins with an overview booklet. The overview booklet is a user's guide, providing information on general awareness raising strategies. It also highlights key messages for citizens and NGOs, governments, and small and medium size businesses.

There follows a set of 6 specific modules that describe different aspects of the mercury issue.

MODULE 1: Introduction to the Mercury Problem
MODULE 2: Mercury in Products and Wastes
MODULE 3: Mercury and Industry
MODULE 4: Mercury Use in Artisanal and Small Scale Gold Mining
MODULE 5: Mercury Use in Healthcare Settings and Dentistry
MODULE 6: Cultural Uses of Mercury

The organization of the modules allows you to go directly to the topic of interest. Each section is presented in a similar way and describes the risks associated with that particular issue and what people associated with it need to know in order to recognize and reduce sources of exposure to mercury and to protect themselves and their communities. Case studies are included, providing examples of how some mercury exposure situations have been handled.

If you believe anything is missing or develop additional materials you think would be useful to others, please provide them to UNEP Chemicals Mercury Programme at the following email address mercury@chemicals.unep.ch. We will consider including them in later versions of this document and/or post the information on our related web-site.

Why has the toolkit been developed?
UNEP Governing Council countries have agreed that there is sufficient evidence of significant global adverse impacts from mercury and mercury compounds to warrant action on mercury.

Many people are unaware of mercury's risks and of sources of their potential exposure. This publication was developed as a response to the need to help raise awareness in certain countries and regions.

What are UNEP's priorities for mercury?
UNEP has the following priorities for mercury and its compounds:

(a) To reduce atmospheric mercury emissions from human sources;

(b) To find environmentally sound solutions for the management of waste that contains mercury and mercury compounds;
(c) To reduce the global demand for mercury related to its use in products and production processes;
(d) To reduce the global mercury supply, including considering curbing primary mining and taking into account a hierarchy of sources;
(e) To find environmentally sound storage solutions for mercury;
(f) To address remediation of existing contaminated sites that affect public and environmental health;
(g) To increase knowledge in areas such as inventories, human and environmental exposure, environmental monitoring and socio-economic impacts.

Is this the only source of information on mercury?
No, there are many places to find additional information on mercury. The information in this toolkit provides a good understanding of the various related issues and provides a basis for general awareness raising. There are also key references included throughout the modules which are of potential value to you in any outreach campaign.

The UNEP mercury website - www.chem.unep.ch/mercury/ - offers an access to many valuable resources, including the Global Mercury Assessment, numerous reference documents and links to specific tools developed by UNEP.

The World Health Organization has also published information related specifically to human health, and many countries around the world have developed assessments of mercury, along with guidance material for their citizens. View the WHO website at: www.who.int/phe.

The United Nations Industrial Development Organization (UNIDO) has some excellent information related to Artisanal and Small Scale Gold Mining available at the following web address: http://www.globalmercuryproject.org/ .

Cover Page: Overview Booklet

a) General Awareness Raising Strategies
b) Key Mercury Messages for citizens/NGOs, local government agencies, and small and medium size companies.

What does it mean to raise awareness about mercury?
The goal of awareness raising is to disseminate factual information to the people who are either affected by mercury or who are in some way responsible for caring for people who may be affected by mercury to inform them about hazards associated with mercury.

Good awareness raising campaigns are optimistic and empowering. They relay responsibility and ownership of an issue to the target audience.

How does one launch an awareness raising campaign?
Before a full mercury awareness raising campaign starts, it is essential to assess the extent of the problem. For instance, it is important to understand the largest source of mercury, the number of people affected, the area or extent of the exposure, the mercury levels in local wildlife and humans, and actions to implement with the greatest potential for environmental benefit.

The overall objective is to promote the understanding of the related issue and associated risks. It is helpful to establish some goals for the effort so that progress can be measured over time.

It is likewise important to be aware of target audiences. You will want to consider who is using mercury, what government agencies and NGOs can influence change. Target audiences often include healthcare providers, governments and parents as caregivers, as well as populations that use products containing mercury or that are directly exposed to the risk through their environment or activities. Schools are another major source of information. Awareness raising campaigns can also reach out to industry to urge them to take action on the issue.

The use of existing social networks may be one of the least expensive and most effective ways to get across information about mercury Speakers can visit schools, and materials can be developed for students that they can then take home to their parents.

Awareness raising begins with the commitment of community leaders. Healthcare providers and religious leaders are very important sources of information for a community, since their advice is generally respected. So, they are important allies in awareness raising. There are many community-based organizations whose charter includes the dissemination of public health information and/or community economic development. Community-based organizations often communicate regularly with other groups with similar goals.

Who is the audience?
Once the objectives for awareness raising are established, target audiences will need to be identified along with specific sub-groups within that audience.

It may prove necessary to plan a variety of activities in order to reach out to the audience. Usually the message must be adjusted to fit the audience and priorities may have to be established. Some aspects to consider could include:

- Who needs the information the most?
- Are there existing networks in place to deliver the message?
- Who is positioned to make decisions?
- Who can influence the decision-makers?

What is the message to be delivered?
The character of the overall message to be delivered is very important. To be effective a message should be relevant to the audience and convince them that they need to take action on the issue. Obviously, the message will vary according to the target audience.

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For example, when addressing an artisanal mining community, the take-home message might be:

1. Using mercury in gold mining practices involves a risk to human health and the surrounding environment. You, your family and your community may be at risk of mercury poisoning.
2. Mercury exposure for miners and their communities can be reduced by following safer practices that effectively extract the gold, are simple to use and cost-efficient.
3. Even the storage, transport and handling of mercury for these purposes create a danger of spills and both of immediate and longer-term exposure to mercury vapour.

How does one deliver the awareness raising message?
The message can be delivered in a number of ways:

- Public meetings and workshops are useful to deliver messages to small groups and can be effective in covering topics in-depth.
- Printed material such as leaflets, posters and/or stickers draw attention to the issue and can be made appropriate for most audiences.
- Large-scale publicity such as signs, radio or television advertisements or public service announcements can also be effective in drawing attention to an issue. Celebrities are often willing to play a role in selling the message.
- On-site training is appropriate when detailed information is required to make a difference. It is often best received from local people and most effective with repeated follow-up.

With all these methods and techniques one must consider what are the most effective means to reach out to the target audience. Messages ought to be delivered in local languages.

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Example: Calling a public meeting
A public meeting may be called in a town or region and a group of people related by a common livelihood or industry invited to participate. In doing so, it is essential to inform and involve community or local government leaders when planning the meeting and to work with these leaders in advance to ensure a common understanding and widespread support for the event. Someone will need to ensure that everyone knows about the meeting and that relevant affected groups are represented.

Good listening skills are one key to success at this meeting and in the follow-up. The attendees will likely be able to contribute additional information about the nature of mercury use and release in their community and provide insight into the local perspective.

Such a meeting could serve to establish a common understanding of the mercury problem affecting the community. The meeting should assist participants in developing a plan to help solve the problem, for example, by persuading people to change certain practices or behaviours in their homes or workplaces. It would be helpful to give examples of solutions that are being successfully applied elsewhere. Some of the case studies in this Toolkit will be useful for this purpose.

What role can the media play?
If the right venue is chosen (newspapers, magazines, radio or television), a great number of people involved in, or potentially affected, can be warned of the risks of mercury exposure. There are many examples of the successful role of the media in community outreach in all regions of the world.

Groups or agencies hoping to effect change with media campaigns need to identify their target audience, which in this case could be both users of mercury, and others in their community who may be exposed to it through spills, waste disposal, or contaminated buildings. Organizers should then select the most effective media venue and provider (e.g., the local radio or TV station or the daily newspaper) most likely to reach the largest number of people in their target audience.

Media campaigns can be expensive if they involve advertising. Some newspapers, radio and television stations, however, may set aside space/time for free public service announcements.

Another effective method is to interest journalists in the campaign and encourage them to write or to report on it. One way of attracting interest is through a press release or writing an article for a community newspaper or magazine. Other effective strategies to attract media interest can include holding a press conference or writing a letter to the local radio or television company to suggest a story on mercury and to offer an interview with an expert.

NOTE TO DESIGNER: This could be placed in a text box.
Preparing a press release
A press release should be simple and direct. It should have a catchy headline and strong lead paragraph, answer the who, what, where, when and how, incorporate quotes of organization leaders or experts where possible, and provide contact details.

Below is an annotated example of a press release that can be used to relay your mercury message[1].

Letterhead
The press release should be on Ministry or other official stationary.

A standard introduction for a press release
FOR IMMEDIATE RELEASE

Who to contact for more information. Include address and phone number:
Contact:_____
Press Officer: _____
Government Communications Division, Lead Ministry: _____
Name and telephone contact: _____

Succinct title that attracts the reader's attraction
For example: Country X puts forth an action plan to protect citizens and the environment from Mercury releases.

Begin with the location and date, followed by an introduction covering all major points
City name, Country name, date and year.

A quote by a government representative is helpful (a Minister is desirable)
A sample quote: 'The mercury action plan, once implemented, will be a concrete step towards sustainable development for our country and will protect our citizens from the harmful effects of mercury.'

[1] This information is extracted and modified from UNITAR Guidance on Action Plan Development for Sound Chemicals Management, 2005. It is available at www.unitar.org/cwg/publications/cw/ap/UNITAR_action_plan_gd_26_apr_05.pdf .

Include information about why this event is newsworthy
Sample background information: This action plan on mercury was developed as part of a XX project, with XX funding. This action plan was developed on the basis of the results of the inventory on mercury use and releases that was developed in our country for this project. The action plan was prepared in consultation with stakeholders and is designed to ensure that our country can plan and work together with all sectors of government and society to strengthen our laws, policies, and practices related to mercury. Every year, people and the environment are needlessly exposed to dangerous chemicals such as mercury. This effort, when implemented, will help to minimise or prevent harm from mercury, providing many benefits to our society both locally and globally. The project, which began in our country in XX (timeframe), will conclude in XX.

Conclude with further contact information
For more information contact (name, telephone number(s), and web address) (if available).

How will you know you have achieved the goal?
Evaluating an awareness raising campaign is an essential step in demonstrating success, enhancing future awareness raising efforts, and sharing lessons learned with others. It need not be complicated.

Setting specific objectives and performance indicators at the outset is critical in evaluating and measuring the success of any campaign.

Outcomes can be evaluated in terms of number of participants at an event, number of materials distributed, etc. Outcome measurements can be important measurements.

Measuring or judging the impact of the activity requires a " before and after" comparison and can be more difficult to measure. Surveys and follow-up visits are often used to evaluate whether the target audience learned and/or made changes as a result of the awareness raising activity.

References:
UNEP 1996, 'Five Steps for Raising Awareness on Ozone Depletion', 1996.

UNITAR Guidance on Action Plan Development for Sound Chemicals Management, 2005.

Key messages for Citizens, NGOs, Health Care Providers

NOTE TO DESIGNER: Key messages could be spread across two pages to make it easy to photocopy.

This section provides a brief summary of information aimed at citizens of developing countries and countries with economies in transition to give them a better understanding of local threats to human health and the environment from various mercury-containing products, emissions from mining or industrial processes, waste disposal practices, etc.

This primer also provides practical recommendations on how both communities and individuals can reduce the risks related to mercury exposure through their lifestyle choices and actions.

How are citizens exposed to mercury?

The most important potential exposure is through inhalation of mercury vapour. Approximately 80% of inhaled mercury vapour is absorbed by the body. Potential exposure routes include:

- mercury spills.
- occupational exposures and/or living close to a facility/industry that emits mercury in its processes:
  - gold mining or smelting of metal ores, manufacture of mercury instruments, chlor-alkali plant, a cement plant, a vinyl chloride monomer production plant, metal or electronic recycling activities, and/or burning waste.

Most individuals are exposed to mercury through certain food sources. Elemental mercury carried in the atmosphere is eventually deposited and taken up in bacteria in aquatic environments and converted from elemental mercury into methylmercury. Methylmercury bio-accumulates up the food chain and is the primary source of mercury in our food.

Factors that contribute to the health effects of mercury exposure include the chemical form of mercury, the dose, duration of exposure, the age of the person exposed, route of exposure and the dietary pattern.

Other exposures can come from:

- exposure to some paints, pesticides or fungicides that contain mercury.
- mercury in products that may break or not be disposed of properly.
- other mercury products such as soaps or cosmetics that are applied directly to people's skin.
- drinking contaminated water with high mercury levels.

How important a problem is mercury?

In some areas and occupations mercury may be a significant problem, while in others it may not be, depending on lifestyle and habits, diet, surroundings, occupation. Many actions can be taken to minimise mercury exposure that require relatively little effort, and cost little or nothing. If one learns to take such actions automatically during normal daily life, potential risks related to mercury may be reduced.

It is important to take whatever precautions are possible to minimise inhaling mercury vapours directly, either in the workplace or at home

With respect to mercury in food, many fish consumers have little or no choice in the type or source of fish they consume, but in general it is vital for people who eat a lot of fish to be aware that:

- Fish is an important source of protein, vitamins, and micronutrients in the diet.
- Smaller, younger or non-predatory fish will have lower mercury levels than large, older predatory species.

Populations or sub-populations (such as subsistence fishing people) with higher than average exposure to methylmercury in food, and individuals with higher than normal sensitivity (such as pregnant women and children) should take steps to reduce their consumption of mercury-contaminated fish.

What can citizens do to reduce mercury pollution and exposure to mercury?

As citizens, we are sometimes able to do much more than we believe we can, once we become aware of what the risks are. In whatever way possible, we should reduce mercury uses, releases, trade and exposures:

- understand the sources of exposure – combustion, products, processes.
- change your habits to reduce or avoid possible exposure.
- understand the hazards of mercury exposure and the main symptoms of over-exposure.
- know which products contain mercury (especially old paints, thermometers, batteries, pesticides, etc.) and where to dispose of them separately in your region so they will not be burned and preferably not broken.
- know where to get information and help with regard to mercury problems.
- always look for mercury-free substitutes if available, ask questions when making purchases.
- help raise awareness about mercury exposure risks with your family and in your community.

Who can help to address the important mercury issues?

The individual modules provide additional details on specific issues and also suggest references on where else to seek out information. Information resources are generally available, if one has access to the internet. In some countries financial and human resources are or may become available to address mercury-related problems. In some places government officials are becoming more aware of mercury problems, and industries are generally taking better precautions in dealing with mercury in processes and wastes, and sometimes in phasing out the use of mercury completely.

Health care professionals are often the first to detect mercury exposure in a community. They can help to raise awareness in a community and to encourage the government to undertake an exposure assessment to determine the level of risk to a specific population. While this is being investigated, consumption rates and dietary preferences need to be analysed for individuals and the community, as well as for their exposure to other contaminants and pathways.

Key Messages for Local Governments

This primer provides a brief summary of information for governments to understand what they can do to protect human health and the environment from mercury.

Governments need to gain an understanding of issues such as:

- where is mercury used in the country?
- which of these uses is most important to the national or regional economy?
- which industries could phase out most mercury quickly if aware of its social and economic impacts?

There are increasing resources available to assist governments and companies to find detailed information on industries and processes, including:

- UNEP (2005) Toolkit for identification and quantification of mercury releases http://www.chem.unep.ch/mercury/Toolkit/UNEP-final-pilot-draft-toolkit-Dec05.pdf
- UNEP (2006) Guide for Reducing Major Uses and Releases of Mercury. www.chem.unep.ch/mercury/Sector Guide 2006.pdf

Reducing anthropogenic mercury releases is a global challenge. The specific methods for controlling mercury releases vary widely, depending upon the application, but they focus mostly on striving to reduce both the supply of and the demand for mercury, including taking the following steps.

- Phasing out all mining of primary mercury;
- Reducing the use of raw materials and products that contain mercury;
- Promoting substitution of mercury-free alternatives for products and processes containing or using mercury;
- Controlling mercury releases through end-of-pipe controls;
- Ensuring long-term storage of surplus mercury; and
- Ensuring a high level of mercury waste management.

Mining of primary mercury

It has been demonstrated that there are sufficient quantities of mercury already in circulation in the global economy to satisfy all feasible demands for mercury. The additional removal of primary mercury from the Earth's crust will only serve to increase the total pool of mercury circulating in the global biosphere. More mercury circulating in the biosphere will, in turn, increase the deposition of mercury and up-take by living organisms, thereby increasing the well-known negative impacts of mercury pollution on human health and the environment.

Raw materials that contain mercury

The best-known raw material containing trace concentrations of mercury is coal. While the concentration is usually very small, the vast (and increasing) quantities of coal consumed, and the special characteristics of mercury that facilitate its volatilisation, lead to large amounts of mercury being emitted to the atmosphere through coal combustion. The mercury content of coal varies greatly from one region to another, and it is often possible to mine coal from a deposit where the mercury content is lower.

Other raw materials responsible for large mercury emissions to the atmosphere include, especially, non-ferrous metal ores (e.g., zinc, lead, copper, gold), from which mercury is liberated during the refining or smelting process. As in the case of coal, different deposits may have very different levels of trace mercury contamination. These sources of mercury emissions deserve to be closely monitored as they may have serious health effects on local residents, depending on such diverse factors as the combustion or smelting process, the height of flue gas stacks, and the prevailing wind direction.

Products and processes that contain mercury
Since there are viable alternatives for nearly all products containing mercury, many countries are implementing a range of measures to reduce or eliminate mercury from products, to reduce or phase out the sale and use of products containing mercury, and/or to encourage measures that are mercury-free alternatives. As long as mercury products continue to be produced and sold, they will lead to occupational and accidental exposures, improper disposal through incineration, and they will contribute to the global pool of mercury in the biosphere. The products already circulating should be separated from other waste and not allowed to be burned or incinerated. Where hazardous waste management programs are in place, the mercury wastes must be properly managed as specified by these programmes.

The main processes that continue to use and release mercury, other than the use of mercury in artisanal gold mining, are the mercury cell process for producing chlorine and caustic, and the acetylene process for producing VCM/PVC, which uses mercuric chloride on carbon pellets as a catalyst. The use of mercury for chlor-alkali production is an obsolete technology, but its replacement has been retarded by the significant investment required to install an alternative mercury-free technology. Nevertheless, many countries have recognized that the overall socio-economic benefits of phasing out the mercury process appreciably exceed the economic costs, and have actively committed themselves to phasing it out.

The use of a mercury catalyst to produce VCM is more difficult to replace in some regions as it relies on inexpensive and large supplies of coal as a raw material. Again, depending on various operating and other factors, both the chlor-alkali and VCM processes may pose a significant mercury risk to local residents, and should be carefully monitored.

Controlling mercury releases through end-of-pipe controls
End-of-pipe controls should be encouraged in order to keep mercury out of the environment in combustion or heating processes giving off significant mercury emissions (e.g., coal burning, smelters, incinerators), in production processes using mercury (e.g., chlor-alkali, VCM), and in the manufacture of products containing mercury. In some cases the mercury wastes from these end-of-pipe controls may be recycled and the mercury recovered, which contributes to preventing pollution and is one source of mercury that helps to replace the primary mining of mercury.

Long-term storage of surplus mercury
One important initiative is the recognition that certain large sources of mercury (e.g., government stocks, mercury recovered from decommissioned chlor-alkali plants) are not needed on the world market, and should be relegated to long-term safe storage. Their sale on the global market increases global supply and drives mercury prices lower, hindering a range of efforts (especially in artisanal gold mining) to reduce the uses and releases of mercury.

Ensuring a high level of mercury waste management
Finally, once mercury is removed from process gases, wastewater, etc., government agents need to ensure that it will stay out of the environment by encouraging a high level of mercury waste management. Otherwise, depending on the treatment and final disposition of mercury wastes, these wastes may continue to pose a very significant risk to the public or to the environment.

Government agents should have a good understanding of the mercury waste produced in their region. How much waste is generated, what type of waste (sludges, filtercake, tailings, ash, slag) is generated, what is the approximate mercury content of the different types of waste? Furthermore, adequate mercury waste disposal facilities (normal landfill, special waste landfill, underground disposal – possibly in another country) should be made available whenever possible, and government agencies should require documentation recording the disposal of such wastes. Meanwhile, it should be kept in mind that excessive waste disposal costs may encourage undesirable or illegal waste disposal practices. Mercury waste should not end up in a situation where it could be burned or incinerated – this will result in the release of the mercury to the atmosphere.

What about artisanal and small scale gold mining?
Artisanal and small scale gold mining (ASGM) is a particularly delicate sector. Governments should work with stakeholders to identify where mercury is being used in ASGM and take steps to educate miners and communities, including encouraging miners to reduce mercury use and to reduce releases through use of retorts. See Module 4.

Key Messages for Small and Medium Size companies

This section is aimed at small and medium size companies using or emitting mercury to permit them to understand better the risks of their activities[2]. It also seeks to reduce the impacts of their business operations, emissions from industrial processes, waste disposal practices, etc., on human health (occupational health as well as impacts on local citizens) and the environment.

Image or reputation of the company in its community
First, it is very useful for a company to have a good working relationship with the local community. If the relationship is good, problems can be more easily resolved, and the local community will be more inclined to trust the proposals or actions of the company.

Mercury management plan
Second, any company that uses mercury in its operations should have a specific written plan for dealing with mercury. This plan ought not only to demonstrate compliance with all government regulations, but cover all of the issues listed below, together with deadlines or milestones for taking certain specific actions or meeting environmental standards, as necessary. In general, the management plan should promote ongoing reductions in mercury uses, releases, trade, and human exposure to mercury. At the same time it should also include emergency management procedures, such as how to deal with mercury spills and with workers who have been exposed to high levels of mercury.

Occupational exposures
The company must determine what occupational exposures to mercury may be experienced by workers. It should have a program for monitoring air concentrations of mercury in the workplace, worker exposures and for dealing quickly with any evidence of harmful exposure. It should also have a plan for ongoing reduction and, if possible, eventual elimination of occupational exposures through changeovers to mercury-free products and processes.

Mercury emissions
Each company should have a fair idea, at any time, of the quantity of mercury used and released through its practices and products. It should be aware that releases may vary significantly depending on the production or process activity rate, the raw materials used, the age and maintenance of equipment, and even the ambient weather conditions.

The factory management should also be generally aware of where its emissions are going – what part of its emissions into the upper atmosphere and deposited far away, what part into the local atmosphere and deposited locally, the direction of the prevailing winds, emissions to wastewater, etc. It is only in such a way that a company can have a reasonable idea of the possible impact of its mercury emissions on the local population and the environment.

Whatever the circumstances, the company also requires a program for ongoing reduction of mercury emissions, possibly linked to the level of production, with milestones and target dates and annual reviews of its mercury monitoring and reduction strategies.

Mercury wastes
The company should have a good understanding of its mercury waste situation. How much mercury waste is generated, what type of waste (sludges, filtercake, tailings, ash, slag, etc.) is generated, what is the approximate mercury content of the different types of waste, under what conditions may waste be stored?

Furthermore, in order to manage mercury wastes adequately, the company has to know precisely where and how its mercury wastes are disposed of. For example, due to the known risks of mercury on human health

[2] This publication is intended to raise general awareness and contains general guiding principles. It does not provide detailed guidance for industry to achieve mercury reductions.

and the environment, it is no longer acceptable merely to transfer mercury wastes to another person or company and blissfully to forget about them. Are the mercury wastes going to a landfill, and if so, is it a municipal landfill or a special landfill? What is the chance that these mercury wastes may be burned on the landfill or elsewhere? What is the risk of mercury exposure to people who may be scouring a waste dump in search of reusable materials?

If the mercury waste is treated, what kind of treatment is used, and how is the waste disposed of after treatment? Is final disposal deep underground and no longer a concern, or is it possible that mercury wastes may still be burned or incinerated? With mercury emissions, the company ought to have a mercury (and other) waste reduction program that targets ongoing decrease of the volume and mercury content of wastes, as well as gradually improving treatment and disposal practices which meet gradually higher standards.

Resources and costs

While some improvements referred to above are obvious, other measures that may be implemented to achieve ongoing reductions in mercury occupational exposures, emissions and wastes are not always evident. However, there are increasing resources available to assist the company to move in this direction, such as:

UNEP (2005) Toolkit for identification and quantification of mercury releases
http://www.chem.unep.ch/mercury/Toolkit/UNEP-final-pilot-draft-toolkit-Dec05.pdf

UNEP (2006) Guide for Reducing Major Uses and Releases of Mercury.
www.chem.unep.ch/mercury/Sector Guide 2006.pdf

There is often a general concern that improvements of various types designed to reduce mercury releases will be prohibitively expensive. While this is certainly true in some cases, there are frequently a great number of measures that may be taken for very little or no cost. Employees may be very happy to help out in various ways when they know that such measures can reduce mercury exposure to themselves or their community. Furthermore, the reduction or elimination of mercury or mercury wastes has often been shown to save money for a company because it no longer has to devote funds to filter flue gases or wastewater leaving the building. The firm can also economize on costly mercury waste disposal.

Proposed Back Cover Page

Governments have agreed that there is sufficient evidence of significant adverse impacts from mercury and mercury compounds to warrant action on mercury. This publication was developed to raise awareness in certain countries and regions amongst stakeholders on the effects of mercury on human health, wildlife and the environment. It is hoped that it will assist citizens, governments and health care workers to build support and the capacity to take action to reduce or eliminate mercury uses and release, and exposure to mercury.

This is the Overview Guide.

To find additional information on mercury and UNEP's mercury programme go to:
www.chem.unep.ch/mercury/

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Cover Page: Module 1

Introduction to the Mercury Problem

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The key messages could go over the first two inset pages so that it is easy to photocopy for the user.

KEY MESSAGES

- Mercury has been used in various products and processes for hundreds of years due to its unique chemical properties.
- Mercury and mercury-containing compounds are highly toxic and have a variety of significant adverse effects on human health, wildlife and the environment.
- In recent years, environmental mercury levels have risen.
- Once released, mercury can persist in the environment where it circulates between air, water, sediments, soil and biota in various forms.
- Atmospheric mercury can be transported long distances in the atmosphere, incorporated by microorganisms and may be concentrated up the food chain.
- Localized hot spots exist from the use of mercury in industrial processes, mining, waste sites, and other air emission point sources.
- Bacterial processes convert some of the mercury deposited in bodies of water into methylmercury, a form that can bioaccumulate up the food chain, becoming concentrated in larger, predatory marine mammals and fish, such as seals, swordfish, shark, marlin, mackerel, walleye, sea bass and tuna.
- In the human body, mercury damages the central nervous system, thyroid, kidneys, lungs, immune system, eyes, gums, and skin. Neurological damage caused by mercury and that has reached the brain cannot be reversed. There is no known safe exposure level for elemental mercury in humans, and effects can be seen even at very low levels.
- The most common exposure to mercury is through ingestion of fish and other marine species contaminated with methylmercury.
- There are two general types of subpopulations susceptible to mercury: those who are more sensitive to the effects of mercury (the fetus, newborns and children) and those who are exposed to higher levels of mercury through their livelihood and/or culture (anglers, subsistence fishers).
- People may also be exposed to elemental or inorganic mercury through inhalation of mercury vapour during occupational activities or spills or through direct contact from mercury use.
- Over the past 50 years mercury's toxicity has been well documented and many countries have taken steps to reduce its uses and releases, and to protect their citizens from exposure to mercury.
- Governments have concluded that there is sufficient evidence of significant global adverse impacts from mercury to warrant further international action to reduce the risks to human health and the environment.

What is mercury?
Mercury is a natural element. In its pure form, mercury is a shiny silver-white metal that is liquid at room temperature.

Where does mercury come from?
Trace amounts of mercury exist in air, land and water due to the weathering of rock and from volcanic activity. Pure mercury is rarely found in nature, but the pure metal is extracted from cinnabar.

Mercury has always been present in our environment and therefore in varying amounts in the foods we consume. Human activities, however, substantially contribute to the mercury in the environment and in the food chain.

Mercury has been used in a wide range of products and industrial processes over the years, but currently most of it is employed in:

- Industrial processes that produce chlorine (mercury cell chlor-alkali plants), vinyl chloride monomer (for polyvinyl chloride (PVC) production, and polyurethane elastomers).
- Artisanal and small scale gold mining.
- Products such as electrical switches (including thermostats) and relays, measuring and control equipment, energy-efficient fluorescent light bulbs, batteries and dental amalgam.
- Mercury is also sometimes used in laboratories, cosmetics, pharmaceuticals including vaccines as a preservative, paints, and jewellery.

There are mercury-free alternatives to most products and processes containing mercury available now in an increasing number of countries (see Module 2).

Mercury is also released unintentionally from other industrial processes, such as coal-fired power and heat generation, cement production, mining and other metallurgic activities such as non-ferrous metals production. Coal-fired power production is today deemed the single largest global source of atmospheric mercury emissions (Pacyna and Pacyna, 2000).

Waste from products and industrial processes containing mercury can be a significant source of mercury release

In addition to releases from human activities, some atmospheric mercury releases come from natural sources (such as forest fires and volcanic eruptions).

Different types of mercury travel different distances. Some kinds deposit within a few kilometers of release, while others are transported throughout the hemisphere before they are deposited.

Historically: **NOTE TO DESIGNER: This could be in a text box.**
Mercury was one of the first known metals and has been used since ancient times for reasons both practical and mystical. For example, the Egyptians and Chinese used the mineral cinnabar (HgS) as a red pigment. Archeologists have found mercury in an Egyptian tomb dating from 1500 BC. The Greeks knew of mercury and used it as a medicine, and as recently as the 20th century mercury compounds were used to treat syphilis.

The dangers of mercury have become more widely acknowledged over the past several centuries. Mercury's neurological effects on hat-makers, who used mercuric nitrate to make felt for hats, were so widely recognized that it led to the expression, "mad as a hatter."

How are people exposed to mercury?
The most important potential exposure is through inhalation of mercury vapour. Approximately 80% of inhaled mercury vapour is absorbed by the body. Potential exposure routes include:

- mercury spills.
- occupational exposures and/or living close to a facility/industry that emits mercury in its processes:
    - gold mining or smelting of metal ores, manufacture of mercury instruments, chlor-alkali plant, a cement plant, a vinyl chloride monomer production plant, metal or electronic recycling activities, and/or burning waste.

Most individuals are exposed to mercury through certain food sources. Elemental mercury carried in the atmosphere is eventually deposited and taken up in bacteria in aquatic environments and converted from elemental mercury into methylmercury. Methylmercury bio-accumulates up the food chain and is the primary source of mercury in our food.

Factors that contribute to the health effects of mercury exposure include the chemical form of mercury, the dose, duration of exposure, the age of the person exposed, route of exposure and the dietary pattern.

Other exposures can come from:

- dental amalgams.
- exposure to some paints, pesticides or fungicides that contain mercury.
- exposure through mercury use and/or spills in a laboratory (see Case Study: Exposure from a mercury spill incident in a school in the Philippines).
- mercury in products that may break or not be disposed of properly.
- other mercury products such as soaps or cosmetics that are applied directly to people's skin.
- drinking contaminated water with high mercury levels.

Who are at risk?

1. **People exposed through their occupation or local industry.** For instance artisanal or small-scale gold miners who use mercury in their gold amalgamation process, their families and local communities.
2. **Newborn and children are particularly susceptible to mercury poisoning** mainly due to their developmental stage.
3. **Exposure to methylmercury during pregnancy can endanger the fetus** and is of concern for women of childbearing age. Methylmercury can cross the placental barrier and studies have shown that methylmercury in a pregnant woman's diet can have subtle, persistent adverse effects on the child's neurological development (Grandjean, 2003, 2004). Pregnant women, nursing mothers and women who might become pregnant need to be particularly aware of the potential harm of methylmercury.
4. **Nursing infants can be exposed via consumption of contaminated breast milk** when mothers are exposed via medical, domestic, medicinal or occupational uses.
5. **Subsistence fishing populations or populations who consume a lot of predatory fish.** This includes subsistence fishing populations, such as some Inuit, and other cultures that consume a lot of fish.

For an example, see Case Study: Mercury Poisoning from grain treated with fungicide in Iraq.

What are the signs and symptoms of mercury poisoning?
The earliest effects of methylmercury poisoning in adults are non-specific symptoms such as paresthesia (weakness of muscles), malaise, and blurred vision. It can cause nausea, lack of appetite, weight loss, abdominal pain, diarrhea, skin burns and irritation, swollen gums and mouth sores, as well as drooling. With increased exposure, more severe symptoms appear such as numbness and tingling in the lips, mouth, tongue, hands and feet, tremors and lack of coordination, vision and hearing loss, memory loss, personality changes, respiratory distress and kidney failure.

Acute exposure to elemental mercury and vapor can result in acrodynia or "pink disease", which is characterized by bright pink peeling palms, fingers, and soles of the feet, excessive perspiration, itchiness, rashes, joint pain and weakness, elevated blood pressure and heart palpitations.

Methylmercury can also cause mental impairments and learning disabilities, cerebral palsy, seizures, spasticity, tremors, and lack of coordination, along with eye and hearing damage in the unborn baby as a result of the mother's exposure. Methylmercury readily crosses the placenta from mother to baby, and also the blood-brain barrier. In addition, organic mercury passes into the breast milk.

How is human exposure to mercury being measured?

Mercury exposures of numerous populations have been monitored by measuring mercury in blood, cord blood, hair, urine and breast milk. The presence of mercury in blood indicates recent or current exposure to mercury. Mercury level in hair is an indicator of long term exposure. The presence of mercury in urine generally represents exposure to inorganic and/or elemental mercury

What is Minamata Disease?[3]

Minamata disease is a form of severe methylmercury poisoning first identified in Minamata, a city on the island of Kyushu in southern Japan in 1956. Between 1932 and 1968, an acetaldehyde plant owned by the Chisso Corporation released effluents containing methylmercury compounds into Minamata Bay and subsequently into the Minamata River and the Shiranui Sea. The methylmercury bioaccumulated in the shellfish and fish that make up an important part of the local diet. More than 200,000 people were exposed to the contamination. This led to chronic poisoning in residents of the coastal areas of Kumamoto and adjoining Kagoshima prefectures. The local public health institute reported in 1960 that the median value of mercury in hair of 1,644 residents of the coastal areas of the Shiranui Sea was 23.4 ppm (range 0 - 920 ppm), while the median value for non-polluted Japanese was 2.1 ppm (range 0.1 - 8 ppm) (Doi and Matsushima, 1962).

Symptoms of Minamata disease include ataxia, numbness in the hands and feet, muscle weakness, narrowing of the field of vision and damage to hearing and speech. Acute cases can include severe sensory disturbance, convulsions and even death.

[3] This information was drawn from a case study written by Aileen Mioko Smith (MPH), Green Action, Suite 103, 22-75 Tanaka Sekiden-cho, Sakyo-ku, Kyoto 606-8203 Japan. email: amsmith@gol.com.

What can you do to protect yourself from harmful effects of mercury?

- Be aware of the risks of mercury and share this knowledge with your family and friends.
- Let your local government and industries know that you are concerned about your health and the well-being of the environment.

What can governments do to protect their citizens and environment?

- Understand mercury use and releases in your country or region through the development of a mercury inventory. The development of mercury use and emission inventories are a good first step in assessing the scope of the problem at the national level. UNEP has developed the 'Toolkit for identification and quantification of mercury releases' to assist countries in undertaking such work. The toolkit is available at the following web address: http://www.chem.unep.ch/mercury/Toolkit/default.htm.
- Find means to control the use, release and disposal of mercury in a country or region.
- Educate citizens, industry and health care workers on the risks of mercury.
- Work with industry, health care workers, citizens and NGOs to develop a mercury reduction strategy.

For an example of the need for national actions, see Case Study: A case for national actions on mercury in Peru.

Mercury in Food

(Note to designer: we would refer this to be together. Perhaps a two page spread.)

- Fish is an important source of protein, vitamins, micronutrients, and the beneficial long-chain of polyunsaturated omega-3 fatty acids in the human diet. Nevertheless, it is important to be aware that fish can be a potential source of methylmercury.
- Methylmercury presents the greatest risks to developing fetuses, infants and children, and exposure can lead to neurodevelopmental disorders.
- Fish in and downstream of mercury hotspots – small scale gold mining operations, mercury cell chlor alkali plants, mercury product manufacturing facilities, metal smelters, coal-fired power plants and certain other industries – can contain high mercury concentrations, but fish in other regions – even the Arctic where there is little or no local mercury pollution – are affected as well.

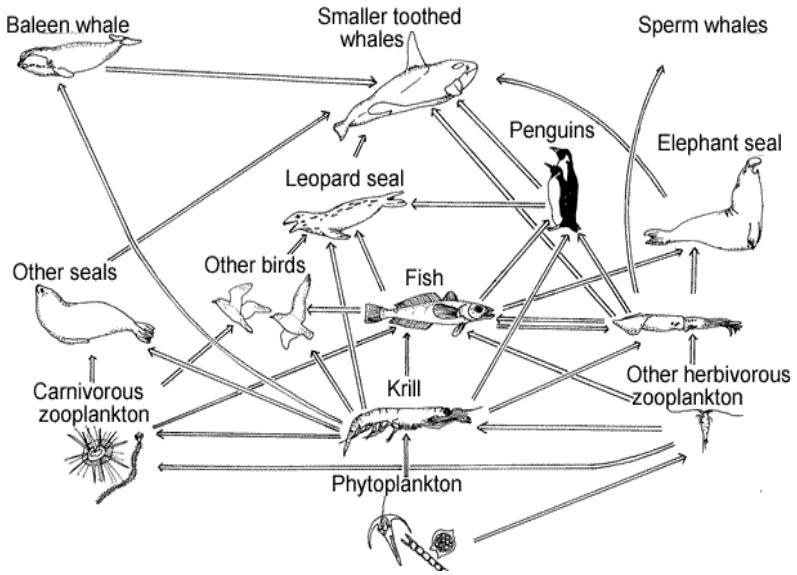
How does mercury get into our food?

Elemental mercury carried in the atmosphere is eventually deposited and taken up in bacteria in aquatic environments and converted from elemental mercury into methylmercury. Methylmercury is what bioaccumulates in the food chain.

Bioaccumulation occurs as larger animals consume smaller ones in the food chain (the food web) (see Figure 1-1). Micro-organisms incorporate methylmercury into their systems, and it is concentrated up the food chain as larger fish eat smaller ones. This is known as biomagnification. Top-level predators in aquatic systems (such as that shown in Figure 1-1) can have levels of methylmercury built-up in their systems that are 100,000 times higher than the surrounding waters in which they live. Ingesting fish, waterfowl, or aquatic/marine mammals that have built up high levels of methylmercury passes their toxic burden along to those who consume them, including humans. Most (about 90 percent) of the mercury in fish is methylmercury and most (greater than 95 percent) of the methylmercury in fish ingested is readily absorbed into the body through the gastrointestinal tract

Due to long-range transport, anthropogenic mercury is found in remote areas far from industrial activity. For example, high mercury levels are observed in the Arctic, far from any mercury sources of significance (see Case Study: Mercury levels in the Arctic).

Figure 1: *The Antarctic food web*
(NOTE TO ARTIST and Designer: this diagram needs a common look to the rest of the document)



What variables affect mercury concentration in fish?
Levels of methylmercury in fish, waterfowl and aquatic/marine mammals vary depending on many factors. While much is known about mercury bioaccumulation and biomagnification, the process is extremely complex and hard to predict quantitatively. In general, mercury levels in fish tend to increase with age and size as a result of the slow elimination of methylmercury and increased intake as fish grow to larger sizes. Therefore, older, larger fish typically have higher mercury concentrations in their tissues than younger fish of the same species.

Methylmercury accumulates in all fish tissue and organs. Most of the mercury present in fish is in the form of methylmercury. Elevated mercury levels have been measured in many freshwater and marine species throughout the world. Factors that influence mercury levels in the fish include age, size, weight, and length of the fish, and characteristics of the body of water (e.g., local contamination, pH, reduction-oxidation potential, and other factors). The mercury concentrations in fish generally range from about 0.05 to 1.4 milligrams of mercury per kilogram of tissue (mg/kg). The mercury concentrations are lowest in smaller, non-predatory fish and can increase many-fold on the way up the food chain.

Global climate change may have implications for the methylation of mercury and its accumulation in fish. Rising water levels, extreme weather events, and deforestation can create conditions that remobilize mercury in sediments.

What can you do?
Many fish consumers have little or no choice in the type or source of fish they consume, but in general it is important for people who eat a lot of fish to be aware that:

1. Fish is an important source of protein, vitamins, and micronutrients in the diet.
2. Smaller, younger or non-predatory fish will have lower mercury levels than large, older predatory fish.
3. Methylmercury in fish is bound to tissue protein rather than to fatty deposits, so that trimming and skinning of mercury-contaminated fish does not reduce the mercury content of the fillet portion. No cleaning or cooking methods are able to reduce the amounts of mercury present in animal or fish protein.
4. Mercury intake depends not only on the level of mercury and the type of fish, but the amount consumed and the frequency of consumption as well.

Populations or sub-populations (such as subsistence fishing people) with higher than average exposure to methylmercury in food, and individuals with higher than normal sensitivity (such as pregnant women and children) should take steps to reduce their consumption of mercury-contaminated fish.

What can governments and health care professionals do?

- Government agencies can issue fish consumption advisories for susceptible populations (the sensitive and the most exposed subpopulations), and may sometimes do so for the general population, to limit or avoid consumption of certain fish and/or waterfowl from specific bodies of water. Advisories would inform the public that high concentrations of chemical contaminants (e.g., mercury and other toxics) have been found in local fish and wildlife. They include recommendations to limit or avoid consumption of certain fish and wildlife species from specified bodies of water or, in some cases, from specific types of waters (e.g., all inland lakes).
- The Joint Food and Agricultual Organization/World Health Organization Expert Committee on Food Additives (JECFA) has established a provisional tolerable weekly intake (PTWI) for total mercury at 5 µg/kg body weight and for methylmercury at 1.6 µg/kg body weight. The PTWI is the amount of a substance that can be consumed weekly over an entire lifetime without appreciable risk to health and is an endpoint used for food contaminants such as heavy metals with cumulative properties
- Governments might first undertake an exposure assessment to determine the level of risk to a specific population. In doing so, consumption rates and dietary preferences need to be analysed for individuals and the community, as well as exposure to other contaminants and pathways.

NOTE TO DESIGNER:

Case studies can be placed throughout module. Some suggestions have been made.

Case Study:
MERCURY POISONING FROM GRAIN TREATED WITH FUNGICIDE IN IRAQ

Methylmercury and ethylmercury poisonings have occurred twice in Iraq following the consumption of seed grain that had been treated with fungicides containing alkyl mercury compounds. The first incident occurred in the late 1950s, was caused by ethylmercury-treated grain, and adversely affected about 1000 people.

In 1971, a larger number of people in Iraq were exposed to methylmercury when imported mercury-treated seed grains arrived after the planting season and were then used to make into flour that was baked into bread. Because many of the people exposed to methylmercury in this way lived in small villages in very rural areas (and some were nomads), the total number of people exposed to these mercury-contaminated seed grains is not known. About 6,500 patients were hospitalized and 459 known deaths occurred, mainly due to failure of the central nervous system.

Toxicity was observed in many adults and children who had consumed the bread over a three-month period. Fourteen Iraqi patients who developed ataxia and "pins and needles" and could not walk heel-to-toe were examined for impaired peripheral nerve function (EPA, 1997). The predominant symptom noted in adults was paresthesia, and it usually occurred after a latent period of from 16 to 38 days. In adults symptoms were dose-dependent, and among the more severely affected individuals ataxia, blurred vision, slurred speech and hearing difficulties were observed (EPA, 1997).

The population group that showed the greatest effects was offspring of pregnant women who ate contaminated bread during pregnancy (EPA, 1997). Infants born to mothers who had eaten the bread exhibited symptoms ranging from delays in speech and motor development to mental retardation, reflex abnormalities and seizures (EPA, 1997). Some information indicated that male offspring were more sensitive than females. The mothers experienced paresthesia and other sensory disturbances but at higher doses than those associated with their children exposed *in utero*.

CASE STUDY:
EXPOSURE FROM A MERCURY SPILL INCIDENT IN A SCHOOL IN THE PHILIPPINES

On 19 February 2006, a 14-year-old boy with symptoms of numbness, redness, and pain of extremities after an exposure to elemental mercury three days earlier was presented to the University of the Philippines National Poisons Management and Control Center at the Philippine General Hospital in Manila. A mercury spill had allegedly occurred in the boy's science class three days earlier unknown to the school authorities.

Initial interviews revealed that two beakers filled with an estimated 100-200 grams of mercury were spilled in the science class during the week. Reports indicate that the total mercury spilled could be estimated at 326-408 g.

It is reported that while the teacher was writing the lessons on the board, the children played with the beaker and spilled some mercury in the room. The children then reportedly applied mercury to their skin, hair and other parts of the body. Some even brought some mercury samples to their homes as souvenirs. Eighty students, ages 13-14 years old and the science teacher were exposed to elemental mercury. The primary routes of exposure were dermal and inhalation. Initially, 10 students were admitted to the hospital because of fever, itchy rashes, difficulty in breathing, chest pain and body malaise, with onset of symptoms 13-16 hours post-exposure. Other signs and symptoms were: headache, pruritus, cough/colds, weakness, muscle pain, dizziness, nausea, numbness, redness/swelling of upper extremities.

The Inter-Agency Committee on Environmental Health constituted by 14 national agencies met regularly to address and resolve health, environment, education and other concerns raised by the mercury spill. These meetings were transparent and participative in nature to ensure that all sectors, including the school representatives, were consulted in the decision-making process. It was evident that there were no existing guidelines for mercury clean-up in schools. The committee has since recommended the banning/phase-out of mercury in schools. Guidelines for the phase-out plan and disposition of available mercury in schools are being developed. The Department of Education is conducting an inventory of mercury (and possibly other chemicals) in schools.

On 26 May 2006, the school was reopened.

LESSONS LEARNED

a) There is a need to conduct information and education campaigns to raise the level of awareness of the various stakeholders on the effects of mercury.
b) Prompt, appropriate and immediate clean-up of the mercury spill should be implemented to reduce or mitigate the impact.
c) Decontamination procedures for all contaminated objects should be immediately implemented, as necessary, and preventive public health intervention measures implemented as soon as possible.
d) There is a need to review/improve/strengthen the Government's capacity to respond immediately and actively to chemical emergencies including rapid assessments. First response programs on chemical incidents in the various settings, i.e., homes, school, hospitals, industry, etc., should also be established. Risk assessment, management, and communication are all important in the chemical emergency response system.
e) There is a need to review school curricula involving hazardous chemicals.
f) Standards and regulations to be adopted are dependent on the situation, susceptible population and prevailing conditions in the environment.
g) Sampling methodologies should consider the characteristics of the most vulnerable population groups (e.g., breathing zones of children compared with adults is closer to the ground and measurements should be taken in this zone).
h) The coordinated approach through the The Inter-Agency Committee on Environmental Health has helped to harmonize and streamline efforts to implement immediate, coordinated, and strategic measures to protect human health and the environment.

ACKNOWLEDGEMENT

This case study was prepared by the Secretariat of the Toxic Substances and Hazardous Waste Sector, Inter-Agency Committee on Environmental Health in the Philippines.

CASE STUDY: A case for national actions on mercury in Peru

In June 2000 a truck with an open flatbed trailer containing nine flasks of elemental mercury (each weighing almost 200 kg), left a gold mine in northern Peru. The Yanacocha mine, operated by Minera Yanacocha S.R.L. (MYSRL) is located 600 km north of the Peruvian capital, Lima. The mercury, produced as a byproduct of the widely used cyanide heap-leaching technology employed in gold mining, was being trucked 600 kilometers to Lima where it was to be exported and sold for use in medical instruments.

The mine is the 4th largest gold producer in the world (around 1.75 million oz in 2000), the largest in Latin America and the world's largest heap leaching operation. As a result of the cyanidation operation, about 1.7 million ounces of silver and 48 tonnes of mercury are produced annually together with the gold. The mercury output has been increasing since the beginning of the operation in 1994 and it represents more than 50% of the mercury produced in Peru.

In Peru, there is no comprehensive set of regulations on the transportation of hazardous materials and the flasks of mercury were packed into the back of the truck with flasks of chlorine, one of which may have come untied and toppled over, damaging a flask of mercury. Unnoticed by the driver, an estimated 151 kg of mercury leaked from the flask, and was spread along a 42 km section of the road as it passed through three villages, San Juan, Choropampa and Magdelena. Where the truck stopped along its journey, larger quantities pooled. Before the spill was discovered and clean-up activities began, residents had found the mercury, children were playing with it, and some people were collecting it in pans and taking it home.

It is believed that some villagers collected the mercury because they thought they could derive economic value from it, by extracting gold and other metals they believed were associated with the mercury. Some residents may have burned the mercury in hopes of extracting gold. Other villagers may have collected the mercury for cultural or ritual use.

Vapours from the spilled mercury affected about 950 people at various levels of intensity. Within a few days, many villagers became ill from handling the mercury and were diagnosed with symptoms of acute mercury poisoning. Overall, 200-300 villagers were diagnosed as having some level of exposure and symptoms.

MYSRL spent US$16 million on a remediation program. The Peruvian Ministry of Energy and Mines requested an independent assessment of the results of the remediation activities. Scientists reviewed the mass balance for the 151 kg of mercury spilled. Soil samples were collected at intervals along the road along the predicted spill area and tested for mercury. The review team estimated that 140 kg of mercury (more than 90% of that spilled) had been removed and transported back to mine for disposal. According to mine officials, residents returned 54.9 kg of mercury in return for a reward of $35 per kilogram. However, mistrust and suspicion toward the company may have led some residents to hold onto the mercury they collected, despite warnings of its risks, in hopes of attaining future economic value from it.

Further measures, such as detailed monitoring programmes to locate additional hot spots on roadsides, were deemed costly and unlikely to succeed, and the risk of methylation of the spilled mercury (transformation to its most toxic form) was judged to be minor due to the success of the clean-up efforts and the environmental characteristics of the region. Nonetheless, it is believed that about 11 kg of mercury are still unaccounted for, of which at least 5 kg have already evaporated.

In the years since the spill, hundreds of people from the three villages reported skin, kidney, neurological, pulmonary, reproductive, respiratory, and vision problems and tested positive for mercury poisoning at area health clinics. The Peruvian government fined the company $500,000, and the company paid additional settlements to some residents and the medical insurance of others.

Lessons learned:

1. Regulations on the transport of dangerous goods should be implemented to prevent and limit the risk of such spills.
2. Early detection of a spill helps to limit exposure.
3. Awareness about the hazards of mercury may have prevented the exposure of many individuals.
4.Good relationships between industry and the community can help with management of spills and

accidents.

For more information, see:
Assessment of Mercury Contamination on Magdalena-San Juan Road, Peru
Marcello M. Veiga, MSc., Ph.D. and Jennifer Hinton, Geo Eng.
Vancouver, BC, Canada, for the Ministry of Energy and Mining, Lima, Peru

CASE STUDY: MERCURY LEVELS MEASURED IN THE ARCTIC

The Arctic region may be considered a "hotspot" for mercury contamination. Studies indicate that approximately 200 tonnes of mercury are deposited north of the Arctic Circle each year, generally far from local sources.

As mercury accumulates up the food chain, the highest levels are found in top predators such as seals, toothed whales, polar bears and humans (NERI, 2004). Mercury levels in Arctic ringed seals and beluga whales have increased by up to four times over the last 25 years in some areas of Canada and Greenland.

Numerous studies have shown that the high level of mercury in Arctic fish and marine mammals has made its way into the human population. Generally, indigenous people rely on traditional diets, culture and lifestyle and have limited access to alternative imported food. Lower-income families tend to rely to an even greater extent on traditional diets and, as a result, are at even greater risk of exposure (Cone, 2005).

Over 50% of the Inuit population on Baffin Island, Canada are exposed to a far higher level of mercury than is considered a tolerable daily intake by the World Health Organization (Chan, 1997). Those consuming the most fish and wildlife have intake levels of mercury six times higher than the provisional tolerable weekly intake of mercury.

Useful Links:
Guidance for Estimating Exposures to Mercury to Identify Populations at Risk
http://www.chem.unep.ch/mercury/Guidance-training-materials.htm

UNEP 'Toolkit for identification and quantification of mercury releases'
http://www.chem.unep.ch/mercury/Toolkit/default.htm

A calculator for determining mercury-exposure from fish consumption can be found at:
http://www.nrdc.org/health/effects/mercury/effects.asp

Pollution Probe: Mercury in the Environment, A primer:
http://www.pollutionprobe.org/Reports/mercuryprimer.pdf

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Acknowledgements:

- Mercury Policy Project
- World Health Organization

Proposed Back Cover Page of each Module

Governments have agreed that there is sufficient evidence of significant adverse impacts from mercury and mercury compounds to warrant action on mercury. This publication was developed to raise awareness in certain countries and regions amongst stakeholders on the effects of mercury on human health and the environment. It is hoped that it will assist citizens, governments and health care workers to build support and the capacity to take action to reduce or eliminate mercury uses, release, and exposure to mercury.

This is one of six modules.

To find additional information on mercury and UNEP's mercury programme go to:
www.chem.unep.ch/mercury/

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Cover Page: Module 2

Mercury in Products and Wastes

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Key Messages

- Due to its unique chemical properties, mercury has been used in a wide range of products over the years, but currently most of it is used in electrical and electronic devices, switches (including thermostats) and relays, measuring and control equipment, energy-efficient fluorescent light bulbs, batteries and dental amalgam.
- Smaller amounts are used in some laboratory experiments and in some cosmetics, pharmaceuticals, paints, and jewelry.
- There are mercury-free alternatives to most products and processes containing mercury and are available now in an increasing number of countries. Manufacturers, brand owners and retailers are encouraged to produce and sell mercury-free products.
- Mercury and mercury compounds cannot be destroyed, but only contained so that they do not circulate in the environment, endangering human beings and wildlife. When products containing mercury are discarded into the general waste stream, the mercury pollutes the environment – in waterways, wetlands, and the air – and endangers people both locally and globally.

WHY IS THIS IMPORTANT TO YOU?

- Mercury is toxic. Being aware of the mercury content of products you currently use and in use around you is important to safeguarding your own health and that of your family.

WHAT CAN YOU DO?

For the Public

- Seek out mercury-free products
- Dispose of mercury-containing products separately, not with other trash.
- Do not dispose of mercury-containing products in trash that will be burned, since the mercury will vaporize and pollute the air.
- Bring the issue of the need for proper waste management to the attention of the leaders in your community and government authorities.

For Health Care Workers

- Educate people about the risks of mercury poisoning, the mercury-containing products they use, and proper spill handling procedures.
- Assess blood or urine mercury levels in people you believe may have been exposed to excessive mercury.

For Governments

- Promote public awareness about what products contain mercury
- Encourage government agencies, institutions, hospitals and industry to choose and procure mercury-free products
- Encourage industries and retailers to switch to mercury-free products.
- Encourage municipalities to establish controlled disposal systems for mercury-containing waste. Establish national or regional safe containment facilities for mercury-contaminated waste.
- Regulate and monitor industries using mercury.
- Regulate the export/import of mercury and mercury-containing products.

Where and why is mercury used in products and processes?

Mercury has been used in a vast range of products over the years. It is liquid at room temperature and has special properties that make it useful in a number of applications. Mercury expands and contracts very precisely in response to changes in temperature.

Mercury is very dense, and it maintains its volume in response to changes in atmospheric pressure. These properties make it useful in devices designed to measure temperature or pressure. In addition, there are a number of components (i.e., parts that perform a specific function in other products) that contain mercury, and these are used as switches and relays in electrical and electronic applications. Many of these devices contain 1000 mg or more of liquid mercury.

Many developed nations have prohibited the use of mercury in manufactured products. So there has been a general shift of mercury product manufacturing operations (thermometers, batteries, e.g.) to developing nations, where there is often a lower level of awareness of the health and environmental benefits of shifting to mercury-free products and processes.

In certain parts of the world where women use cosmetic products, such as creams and soaps, that promise to lighten their skin, mercury is often put into these products as a common pharmacological compound (further information is provided specifically on this on page XX of this module).

What is the concern with mercury in products and processes?

When products containing mercury are discarded into the general waste stream, they often end up in the environment – in waterways, wetlands, roadside litter, landfills or open dumps, where they may be burned. The mercury they contain is ultimately released into the environment.

The only sure way to reduce human-generated mercury pollution from contaminating the environment is to eliminate its use entirely and to place pollution control devices on facilities that release mercury.

Which products contain mercury?

NOTE TO ARTIST/DESIGNER: A DIAGRAM MAY BE USEFUL HERE.

Mercury is used in a number of products, including electrical and electronic devices, switches (including thermostats) and relays, measuring and control equipment, energy-efficient fluorescent light bulbs, batteries and dental amalgam, and laboratory chemicals.

Mercury also tends to be used in many different ways in hospitals, clinics and doctors' offices for measuring instruments. See Module 5.

Mercury-containing products have been categorized as measuring and control devices, components and other products containing mercury.

Measuring and Control Devices

- Thermometers used to measure body temperature, environment temperature, and certain industrial processes. Prometers that measure extremely high temperatures, such as in foundries.
- Certain thermostats to control temperature.
- Barometers and manometers used to measure pressure.
- Hygrometer to measure the moisture content of contained air or gas; psychrometer to meaure outdoor humidity.
- Hydrometer to measure density or specific gravity of a liquid.
- Flow meter to measure the flow of gas, water, air and steam.

- Common medical devices, such as sphygmomanometers (which measure blood pressure), laboratory and patient-care thermometers and gastro-intestinal devices. Additional information on measuring and control devices can be found in Module 5.

Components
Components such as switches, relays and sensors sometimes use mercury's unique physical properties for activation.

Float and tilt switches are commonly used in automobiles, light switches, thermostats, irrigation pumps and certain industrial processes. Temperature and pressure switches are also employed in certain industrial processes.

Relays rely on magnetic properties:
- Displacement/plunger relays are used in high current, high voltage applications such as industrial process controllers, power supply switching, resistance heating, tungsten lighting, welding, high current/voltage lighting, flood lights, copiers, battery chargers, energy management systems, and industrial ovens.
- Wetted reed relays are used in electronic devices for switching or signal routing, test, calibration, and measurement applications.
- Mercury contact relays are used in certain electronic devices.

Flame sensors or thermostat probes are sometimes used in gas appliances where mercury in the bulb of the sensor vaporizes and expands when the pilot light (flame) is on, causing the gas valve to open, and contract, closing the valve and stopping the flow of gas, when the flame goes out.

Other Products Containing Mercury
Button cell batteries contain 0-25 mg of mercury (and sometimes more) and are often used in watches, hearing aids, calculators, toys and novelty items that light up or make noise. Other specialty batteries (especially mercury oxide or "mercury" batteries) use more than 25 mg of mercury and are often used in hospitals, military facilities and commercial applications.

Lamps (long fluorescent, compact fluorescent, high-intensity discharge (HID), high-pressure sodium, metal halide, neon, mercury vapor) use mercury. 5-50 mg mercury as mercury vapour is used, which, when energized, emits ultraviolet energy. This generates visible light when it reacts with the phosphor coating on the inside of the lamp.

In some countries mercury oxide is used in paints as a red pigment, and mercury is also sometimes used in paint as a fungicide, preservative and antimildew agent. Mercury continues to used as a biocide in homes and industry (paints, glues, wood preservatives), leather industry (tanning solutions), agriculture (seed protectants), and in the wood pulp and paper industry.

Certain Cultural uses, such as jewellery or alloying of religious items such as Parad in India (see Module 6).

Certain pharmaceuticals and soaps (as an antibacterial agent or antiseptic, covered later in this module), traditional medicines (see Module 5: Mercury use in Healthcare Settings and Dentistry).

Dental amalgam, commonly referred to as "silver" fillings (see Module 5: Mercury use in Healthcare Settings and Dentistry).

Mercury and compounds containing mercury are widely used in laboratory solutions, diagnostic reagents, catalysts, slide preparations and sample preservatives for conventional modern healthcare, veterinary medicine, schools and universities and industry.

How does the mercury in products get released?
Mercury in products can be released at various points in the product's lifecycle:

- Emissions and wastes generated during the production of the mercury (whether mined, by-product, recycled, etc.) used in the product
- Emissions during the product manufacturing phase
- Release through normal product use, as in the case of dental amalgams, cosmetics containing mercury, etc.
- Release due to breakage during use (e.g., fluorescent lamps and glass thermometers)
- Release due to breakage in the waste stream (e.g., fluorescent lamps) or through dumping
- Releases during the recycling process
- Releases associated with treatment and final disposal of mercury waste (whether through burial, incineration or reuse of waste materials (e.g., in cement))

It is difficult to quantify the contributions from various sources. Much of the mercury used in products will eventually be released into the environment, either in dumps, open trash burning or when incinerated. In many parts of the world informal disposal allows toxins to enter the environment directly. Furthermore, even some of the mercury treated and disposed of under more controlled conditions, such as to designated landfills, may also be released to the environment over a longer period of time.

UNEP has posted a "Toolkit for identification and quantification of mercury releases" that is a great aid in the preparation of substance flow assessments for mercury. Releases from products via normal use, spills, breakage, scrap metal processing and disposal are generally expected to be significant sources of mercury releases.

What are the risks?

Occupational exposure risks are generally high for those who work in environments where mercury is used to manufacture products.

People are also exposed to elemental mercury when devices containing mercury break. Mercury spills pose risks. The most common exposure routes are through inhalation or through contact with the skin.

Use of mercury products and devices can also affect the downstream environment. Waste containing mercury, including the remains of a cleaned-up spill, often ends up in aquatic environments and the atmosphere through improper disposal.

Are there alternatives to mercury in products?

There are commercially available mercury-free alternatives that can be purchased as substitutes for nearly all products containing mercury in an increasing number of countries.

Substitutions are generally cost-effective, and increasing demand will make them even more so over time. Furthermore, when considering the lifetime costs of the disposal of mercury-containing products, the cost-effectiveness of alternatives becomes even more convincing.

A useful starting resource is the 'Guide for Reducing Major Uses and Releases of Mercury' UNEP 2006. This document is available at the following web address: http://www.chem.unep.ch/mercury/Guidance-training-materials.htm

Lamps with mercury in them remain the standard for energy-efficient lamps, where ongoing industry efforts to reduce the amount of mercury in each lamp are countered. At the time of this publication, there were alternative lower-mercury lamps (3-5 mg of mercury instead of 20-40 mg). There are indications that mercury-free alternatives will become available in the coming years, but for most applications the alternatives are still quite limited and/or quite expensive.

What can you do?

Safeguard the environment by choosing alternatives to mercury-containing products. Share this information with others.

What can governments do?
Substituting products without mercury for products containing mercury is one of the most powerful preventive measures for influencing the entire flow of mercury through the economy and environment.
NOTE TO DESIGNER: DENMARK CASE STUDY could go here.

In some cases, the use of products with lower mercury content should be considered, or a system of separate collection of mercury products instituted– together with an awareness raising campaign to reduce mercury in the waste stream.

A government could regulate the manufacture, sale and/or trade of mercury in products. Sometimes a ban on mercury-containing products may not be politically or practically feasible (e.g., energy-efficient lamps) or implementation may not be well enforced.

Taxes imposed on products with mercury may be a more effective way to encourage a shift to alternatives. Labelling of mercury-containing products is a good way to raise awareness, improve proper handling and encourage use of alternatives. Product labelling has advantages and disadvantages, but has proven rather effective in combination with other measures. For example, in the case of consumer batteries, many consumers pay close attention to labels concerning the content of mercury and cadmium.

Government procurement officers have a tremendous opportunity to safeguard the environment by learning about alternatives to mercury-containing products that they purchase and seeking out mercury-free alternatives. Governments frequently share such information in the overall public interest to procure non-mercury alternatives. [See further details at Link: www.Informinc.org]

What about companies manufacturing, using and/or buying and selling these products?
General information for industries using mercury in their processes is included in Module 3: Mercury and Industry.

Companies that are selling mercury containing products should be aware of the mercury risks and share information about the alternatives to mercury containing products with their customers. Wherever possible, companies should aim to sell mercury-free products.

What are the barriers to adoption of mercury-free products?

There are economic and social barriers to the adoption of new mercury-free products, for manufacturers, sellers, and consumers. In most cases, the barriers can be overcome with the assistance of an appropriate government or local administration strategy or program of information and incentives.

Manufacturers may have concerns about the costs associated with changing their product or process:

- Need for additional development and testing in order to ensure that the alternative product or component meets the necessary standards
- Concern that competitors may continue to produce and market mercury-containing products at a lower cost than the mercury-free alternative
- Knowledge of alternative techniques for producing mercury-free products
- International standards that require, or appear to require, the mercury-containing product
- Costs of packaging and marketing changes in the manufacturing process.

A switch to mercury-free alternatives for consumers can be made difficult by:

- Lack of information and awareness of mercury's risks and the availability of alternatives
- Cost of replacement and/or higher cost of mercury-free alternatives
- Retailers' and consumers' lack of access to suppliers of mercury-free alternatives.

- Scientific and medical labs may have significant barriers to change. Some of the present standards were developed around the use of certain mercury compounds, and they are sometimes considered necessary in order to reproduce reliably certain analyses. In addition, technicians tend to favour the procedures they know well and have long used.

Case Study: Denmark
Mercury Reduction and Substitution in Products

In recent years Denmark has determined to encourage substitutes for mercury products, including placing a ban on the sale and use of most mercury products. As in a number of other countries, a substantial decrease in mercury consumption for intentional uses has been observed. During the period 1983-1993 the annual consumption of mercury in intentional uses fell from about 16 metric tons in 1982/83 to 6 metric tons in 1992/93, and decreased further to 1.5 metric tons in 2000/2001. In the same period, releases to the environment declined from an estimated 6.9-9.9 metric tons in 1983, to 2.3-3.0 tons in 1993 (of which 0.3-0.8 tons originated from trace amounts of mercury in fuels and minerals). The deposits in controlled landfills have increased during the same period from 1.7-2.9 metric tons to 2.3-4.5 tons, most likely as a result of increased hazardous waste collection (reflecting the mercury content of used products, batteries, etc.) and improved filtering of waste incinerator emissions.

What skin care products contain mercury?
(NOTE TO DESIGNER: this could be a two-page spread)
In certain parts of the world people, particularly women, use cosmetic products such as creams and soaps that promise to lighten the color of their skin. Mercury is a common pharmacological compound used in skin lightening creams and soaps.

Regional Examples:
The use of skin lightening products in African nations is very common. Studies show that the percentages of women using such products regularly in Senegal, Mali, Togo, South Africa and Nigeria are 27%, 25%, 59%, 35%, 77%, respectively (del Giudice *et al*., 2002; Greer, 2004). Many women use these products for long periods, sometimes for as long as 20 years (del Giudice *et al*., 2002; Mahe *et al*.; Pitche *et al*.).

In 2004 more than one third (38%) of women surveyed in Hong Kong, Korea, Malaysia, the Philippines and Taiwan use skin lightening products, up from 34% in 2002. In a survey carried out in June 2004 61 percent of respondents in Hong Kong, Malaysia, the Philippines, South Korea and Taiwan said they felt they looked younger with a fair complexion.

What are the risks?
- Mercury use in cosmetic products can have adverse effects including skin rashes (contact dermatitis and acne venenata), discoloring and scarring (post inflammatory dyschromia), and can reduce skin's resistance to bacterial and mycotic skin disorders (Doe, *et al*., 2001).
- Direct and prolonged exposure through the skin during repeated applications can cause damage to the brain, nervous system and kidneys (Appel, 2006).

What can you do?
- If you do use skin lightening products, only use those with labels that you understand and that do not contain mercury or mercury compounds. If you are uncertain, check with local authorities to determine whether the labels are valid and correct.
- Tell your family and friends about this problem and warn them to read labels.

What can governments do?
- Skin care products known to contain mercury should be banned from manufacturing or import and removed from the market when found.
- The health department should warn consumers about specific products known to contain mercury, by brand name and, if possible, with photographs of packaging.
- Anyone using such a product should be advised to discontinue its use immediately, and see a doctor for a medical evaluation.
- The health department, healthcare organizations and consumer advocacy groups should jointly or separately educate consumers through consumer advisories in whatever media are most likely to reach the part of the population using skin lightening products (generally women).
- Advisories should warn:
  - of the potential for mercury poisoning and the ramifications of continued use.
  - not to use skin lightening products containing mercury or any of its forms (quicksilver, cinnabaris (or mercury sulfide), calomel (or mercury chloride) or hydrargyri oxydum rubrum (or mercury oxide) and mercury iodide).
  - not to use products which do not list ingredients or whose ingredients are in a foreign language they cannot understand.

What are some examples of local government actions to protect consumers from these products?

The Indonesian Food and Drug Control Agency (BPOM) issued a warning in 2004 against 51 beauty care products containing mercury and a carcinogenic dye that were being imported. After surveying the population in all provinces, the BPOM found dozens more imported cosmetics containing dangerous chemicals, including mercury. Imports were not the only culprits, however. In late January 2006 the police in Jakarta seized 200 boxes of cosmetic products containing mercury from a small manufacturing company in West Jakarta.

The mercury content in a number of skin creams on the market in Saudi Arabia was tested, with the following results: Daifu (herbal formula/pearl cream) (mercury content 271 ppm), Yin Fong (extra pearl cream) (mercury content 389 ppm), Ginseng (extra pearl cream) (mercury content 467 ppm), Butae (pearl cream) (mercury content 518 ppm), Ginseng (extra pearl cream) (mercury content 595 ppm), Orrefor (extra pearl cream) (mercury content 913 ppm), Bivong (mercury content 929 ppm), Cream Minerva (mercury content 1282 ppm), ALFA (extra pearl cream) (mercury content 1319 ppm), Civic (nourishing cream) (mercury content 1965 ppm), and Diana (mercury content 5650 ppm).

The Kenya Bureau of Standards issued a public notice in the media in 1998-1999 to inform and educate consumers about the harmful effects of mercury, hydroquinone, and hormonal preparations and oxidizing agents contained in some cosmetic products available on the market. These products did not comply with approved standards and the products had been inappropriately used for skin lightening, purposes. The prohibition/ban is aimed at protecting unsuspecting consumers and discourages dumping of these products in the Kenyan market. Products identified containing mercury and its compounds: MOVATE, MEKAKO, JARIBU, TURA, ACURA, RICO, FAIR LADY, ELEGANCE, MIKI, JAMBO, PIMPLEX MEDICATED CREAM, NEW SHIRLEY MEDICATED CREAM.

In January 2005 the City of New York 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. At the time, the following products obtained from store shelves listed mercury among their ingredients: Miss Key Crema Blanqueadora, Santa Cream, Dermaline Skin Cream, Jabón Germicida (soap). These four products were all manufactured in the Dominican Republic, but the City of New York Health Alert notes that such skin lightening products are also manufactured in European, African and Asian countries.

The European Community Directive 76/768/EEU (and its amendments 2000/6/EU and 2000/11/EC) on the approximation of the laws of the member states relating to cosmetic products. This Directive stipulates that mercury and its compounds may not be present as ingredients in cosmetics, including soaps, lotions, shampoos, skin bleaching products, etc. (except for phenyl mercuric salts for conservation of eye make-up and products for removal of eye-make-up in concentrations not exceeding 0.007 percent weight to weight).

Waste Disposal

(Note to Designer: prefer a mini-section here)

Why is waste disposal an issue?

The way that the waste produced in the course of human activity is collected, handled, stored and disposed of can often negatively impact upon public health and the environment. Inadequate or improper disposal of waste results in the leakage of toxic material, such as mercury, into the environment where it endangers wildlife and humans.

Issues of municipal solid waste management are of growing importance as more becomes known about the risks. Rapid population growth has overwhelmed the capacity of many municipal authorities to provide even the most basic waste management services.

What happens to the mercury in products that are disposed of?

When products containing mercury are disposed of and broken or burned and the mercury escapes from them, it begins to circulate in the biosphere. Mercury can change forms, for instance from a liquid to gaseous form or from elemental mercury to methylmercury, but it cannot be decomposed or destroyed or broken down into less harmful elements because it is a natural element.

Mercury released in a landfill may be exposed to the air and volatilize, or, unless the landfill is specially designed, may enter leachate and eventually reach the groundwater.

Municipal solid waste in many areas of the world is dumped in an uncontrolled manner, often into ravines or wetlands near residential areas or disposed of through open burning. Toxic releases and effluent enter ground water and bodies of water both nearby and downstream. In some places, periodic clearing of the wastes accumulated in open piles is accomplished with wheeled loaders and open trucks, which raise significant dust and aerosol exposure hazards. In other places waste is burned in the open, releasing toxic smoke.

The disposal of mercury and mercury-containing products is particularly problematic where waste is burned, as the mercury volatilizes and enters the air. Thus mercury should never be burned. Uncontrolled flue gases from waste incinerators, and open burning of waste releases mercury from mercury-added products into the air and falls back into our waterways and onto the land.

Volatilized gaseous mercury can be transported long distances in the air, but will eventually settle back to the earth. Mercury can also make its way into wastewater, particularly when mercury-containing laboratory chemicals, or products such as dental amalgam, are flushed down the drain, winding up in sewage sludge or passing along into the surface water system. When sludge is burned, the mercury is released to the air. If the sludge is spread on agricultural fields, the mercury escapes into the air, goes into soil and may be taken up by plants, or it may run off into surface waters, become methylated and be taken up by fish.

How should hazardous material in the waste stream be handled?

Hazardous material, which carries potential risks at all phases of handling and disposal, should be identified and contained so that people who handle this waste will not be harmed, and hazardous materials, vapors and wastes will not enter the environment. Mercury is one example of such a waste. It is found in products discussed in this module and sometimes in waste resulting from cultural, medicinal, or religious uses (see Modules 5 and 6).

In order to avoid or limit exposure due to mercury in wastes, various precautions should be taken:

- Mercury containing products should be segregated from other waste before disposal;
- If stored, the waste should be kept in closed containers in order to prevent any leaks or vaporization;
- Mercury-containing waste should never be burned or incinerated unless special flue gas controls are in place to capture the mercury;
- Mercury wastes may be recycled and the mercury recovered, as long as special precautions are taken that all mercury emissions from this process are below internationally agreed standards;

- Very low concentrations of mercury in waste may be discarded to an approved landfill;
- Other mercury wastes may be treated and then disposed of only in a special hazardous waste landfill, or in deep underground disposal.

The proper management of hazardous materials requires a combination of approaches involving technology, legislation, enforcement and funding. Developing a national or regional hazardous waste management system requires significant financial investment, both up-front and during operation. Up-front costs include site preparation, permitting, construction and equipment. Operating costs include labor, supplies, fuel for the machinery handling the waste, record keeping and reporting, and providing training and resources for employee safety and health. Even when a site is eventually closed, there are ongoing costs of monitoring and managing it, and meeting regulatory requirements.

Because of financial constraints, hazardous waste facilities have not yet been constructed in many countries, particularly in the developing world. Should there be insufficient resources to implement a full hazardous waste management process, priority should be given to the separation of hazardous and non-hazardous waste as well as proper storage of the hazardous waste.

What if mercury is spilled in the home or a public place?
Oftentimes elemental mercury is released in the home or in a healthcare facility when a mercury-added product or instrument is broken (e.g., fever thermometers, fluorescent bulbs, laboratory or medical instruments). When dropped, elemental mercury breaks into tiny beads that spread across the floor, and these can easily become trapped in small cracks. Elemental mercury does not readily absorb through the skin, although it should not be handled, even with latex gloves. The primary health danger from a spill is the inhalation, over time, of vapor coming from mercury particles that are left scattered around a living area or workplace. Mercury spills are particularly hazardous in enclosed spaces, and especially to children, because mercury vapor is heavier than air and settles to the floor. It is therefore essential to manage mercury spills properly. Although mercury may look like small beads on the floor, it requires a special cleanup procedure so that the problem is not made worse.

Local health or waste management authorities should familiarize themselves with procedures for the clean-up of spills, and should work with the local authorities to publicize these instructions for the public. These instructions are shown on the next page. Healthcare providers and the public ought also to have access to appropriate storage and disposal facilities for mercury-contaminated waste.

Guidelines for Managing a Small Mercury Spill

In the case of a small spill (e.g., a broken thermometer):

- Remove people (particularly children) from the area of the spill.
- Do not allow children to help clean up. If a child spilled the mercury, assume their clothes are contaminated. Remove the clothes and put them in a sealed plastic bag.
- Open doors and windows to ventilate the living or working area. If possible, keep the temperature below 20°C to reduce the speed at which mercury volatilizes into the air.
- If there is broken glass, pick it up carefully using a glove. Put it into a sealable hard-sided container.
- Use cardboard or folded paper to make a small scoop to gather the mercury "beads." DO NOT use a broom or a vacuum as these will merely spread the mercury around. Use adhesive tape, an eyedropper, or some shaving cream on a small paintbrush to pick up the smaller beads of mercury and seal them in a plastic container. Do this slowly and carefully so that the beads do not scatter.
- Use a flashlight to look for any additional mercury beads that may be sticking to the surface or in small cracked areas of the surface. Mercury can move surprising distances on hard-flat surfaces.
- If the spill occurs on carpet or upholstery, cut out the affected area and seal it in a plastic bag.
- Never pour mercury down a drain or put mercury-contaminated clothing in a washing machine. The mercury may get stuck in the plumbing and remain in the living or working space, slowly volatilizing. If discharged, it can pollute the local waterways.
- If the mercury spills down the drain, take apart the plumbing and remove any mercury from "J" or "S" traps. If you leave it there, it will release toxic vapors into your living or working area.
- If you have some, powdered sulfur makes the mercury easier to see and keeps it from volatilizing. If you sprinkle powdered sulfur in the spill area, and it turns brown, then there is mercury remaining. If you sprinkle it and it stays yellow, there is no mercury left. Remember that this sulfur will stain fabrics.
- If there is mercury on shoes, take them off so they do not spread the mercury around.
- Dispose of contaminated clothing, carpeting, upholstery, etc., in sealed plastic bags and label them as hazardous waste. Place the bags outside and inaccessible to children and animals and ask the local authorities how to properly dispose of them. If there are no hazardous waste disposal options, dispose of the contaminated material in a way that minimizes exposures to people and the possibility that the mercury could be spread back into inhabited areas.
- Keep windows open for a day to ventilate the area of the spill completely. Meanwhile keep people away from the area.
- Monitor anyone who may have been exposed for signs of exposure, such as tremors, pink disease or neurological symptoms. If you have concerns, consult a medical person. Doctors can identify exposure and health risks by measuring the amounts of mercury in blood, urine, breast, milk, fingernails and hair.
- Replace the broken device with a mercury-free alternative.milk, fingernails, and hair.
- Replace the broken device with a mercury-free alternative.
-
- *Source: This procedure has been adapted from the USEPA website http://www.epa.gov/mercury/disposal.htm*

- **What can governments do to reduce mercury exposure from the waste stream?**

Governments can enact policies that result in the reduction of mercury in the waste stream and can promote technical alternatives to the use of mercury in products. Both regulatory and technical measures may be considered.

Example: In 1993 Sweden banned or phased out the manufacture, import and sale of thermometers, barometers, manometers, tilt switches, float switches, pressure switches, thermostats, relays, and other types of measuring instruments.

REGULATORY MEASURES

Regulations might be used to mandate and fund a mercury waste collection, management and storage programme whereby mercury waste is taken from hospitals, individual homes, industrial sites and elsewhere, and stored in a secure location (see surplus mercury management box). Mercury thermometer exchanges—where individuals exchange their mercury thermometers for digital devices—could form part of such a program.

Some regulatory measures include economic or financial incentives. For example, if all mercury-containing products are taxed because they embody potential hazards, then there will be some financial incentive to switch to mercury-free alternatives. If the proper disposal of hazardous wastes is expensive, it will encourage industries to decrease their generation of hazardous wastes. Funds generated from such measures can be used to promote the retirement and safe disposal of already-purchased mercury and mercury-containing products.

Governments could mandate Extended Producer Responsibility for mercury containing products. Under Extended Producer Responsibility, manufacturers and/or importers of mercury-containing items would be charged advance fees that would be used to pay for spills and clean-ups, all of which would make mercury less economically desirable. Such schemes may also include product take-back policies, information and labeling requirements, and deposit / refund schemes.

Other potential regulatory measures are:

- Prevent or limit the intentional use of mercury in products and processes. Prevent or limit products containing mercury from being imported, marketed nationally, and exported.
- Require mercury-added products to be labeled and include information on proper disposal.
- Require mercury-added products to be segregated in the waste stream and their mercury either recycled or disposed of as hazardous waste.
- Put in place an environmental management strategy that includes responsible monitoring and enforcement of mercury regulations, tracking of all mercury movements (from raw material to process to product to waste), and periodic independent assessment.
- Require that any mercury contained in industrial process wastes be recovered.
- Control the marketing and sale of recovered or recycled mercury.
- Prohibit illegal dumping of wastes.
- Control and restrict cross-border transport of mercury and other hazardous wastes.
- Require that any mercury containing waste or materials stored on-site by an industry or commercial operation must be in air-tight and waterproof containers, and that the organization must have complete records and a written plan and schedule for proper disposal of the materials.
- Require industries manufacturing mercury products to prepare a mercury balance each year showing how much mercury entered the process and how much was emitted.
- Require landfills to be licensed and equipped for the type of hazardous waste they accept.

TECHNICAL MEASURES

- The Basel Convention on the Control of Transboundary Wastes and their Disposal has developed relevant technical guidelines on environmentally sound management of household waste that are a good starting point in addressing hazardous waste such as mercury. The following web-

link provides a link to a number of Basel Convention technical waste guidelines: http://www.basel.int/meetings/sbc/workdoc/techdocs.html

In general:

Pre-treatment measures for mercury waste may include prohibiting or limiting mercury releases to the environment by separating mercury and mercury-containing items from household waste, hazardous waste and medical waste.

Governments can play a role in assisting facilities to accept hazardous waste, such as have membranes to prevent mercury from evaporating or leaching, collection and treatment of landfill effluent, routine and long-term testing of groundwater quality and air emissions.

Some emission control measures could include:

- Prevent or limit use of obsolete technology and/or require use of best available technology to reduce or prevent mercury releases
- Ensure that mercury wastes are incinerated only at facilities equipped for hazardous waste, with best-available-technology (e.g., dust collectors and flue gas control)
- Develop a facility (perhaps jointly with a neighbouring country) for final disposal or containment of mercury (and other) treated wastes that are so concentrated or hazardous over the long term that they cannot be responsibly disposed of in any other manner.

Surplus Mercury Management

Note to designer: could be a text box.

A surplus mercury management facility is designed to prevent mercury release to the environment and exposure risks to humans. There should be a well-ventilated, designated location for the storage of waste mercury collection drums. These steel drums must have liners and be placed on a concrete slab. Drums have to be protected from rainfall and be secured from theft and/or to protect against unauthorized opening. Broken and/or obsolete mercury medical devices may be placed in these drums along with mercury from clean-up operations (following facility mercury spill clean-up procedures). Such facilities should develop a waste mercury collection plan which includes procedures and outlines responsibilities. Before beginning there must be an established schedule for when the mercury will be removed for processing, proper management and disposal.

Waste incineration

NOTE TO DESIGNER: This could be a two page spread.

Incineration is one of several centralized waste management approaches used throughout the world. A variety of categories of waste are incinerated, including municipal solid waste, medical waste, sewage sludge and hazardous waste. With its low boiling point, most of the mercury in wastes that are incinerated is thermally released during the combustion process, and will be emitted directly to the atmosphere and return to the earth through rain or dry deposition.

The mercury concentrations in the waste stream are directly dependent on the inputs of mercury to the waste, and will therefore likely vary greatly between different countries and circumstances. The mercury content in the general waste stream originates from three main groups of inputs of mercury:
1) intentionally used mercury in discarded products;
2) natural mercury impurities in high-volume materials (plastics, paper, etc.) and minerals; and
3) mercury as a human-generated trace pollutant in high-volume (e.g., recycled) materials.

The mercury content of municipal solid waste will depend on the prevalence of mercury containing products in the waste, as well as the extent of specific collection systems for mercury containing waste products. Typical sources of mercury in municipal solid waste include, among others, batteries, discarded electrical equipment, fluorescent lamps, dental waste, paint residues, and so on. Depending on the life-time of the various products, the sources of mercury in the waste will reflect the use of mercury in different products a number of years before the mercury enters the waste stream.

Medical waste is considered to be waste generated by a variety of medical and veterinary care facilities including hospitals, clinics, doctors' and dentists' offices, nursing homes, veterinary clinics, medical laboratories, and medical and veterinary schools and research units. Medical waste includes a great variety of disposable bandages, blood, pharmaceuticals and other materials and equipment used for the medical treatment of people or animals. To destroy viruses, bacteria, and pathogens effectively, this waste is often disposed of by incineration. Medical waste is sometimes incinerated in dedicated incinerators, and other times in selected municipal waste incinerators equipped for the purpose.

Available information indicates that medical waste incinerators can be significant sources of mercury emissions. The mercury content in the medical waste stream originates primarily from mercury in discarded products and chemicals, including thermometers, dental material with mercury amalgam, batteries, laboratory chemicals, pharmaceuticals, fluorescent lamps, high-intensity discharge lamps (mercury vapor, metal halide, and high-pressure sodium), special paper and film coatings, and pigments. Mercury sources ought to be separated from the waste stream before incineration, if possible.

An issue of concern for both medical and municipal waste incinerators is the disposal of residual ash that may be high in mercury content, and the mercury that is captured by pollution control systems.

Sewage Sludge

Much of the mercury in municipal wastewater (originating from various sources, but often dominated by dental amalgam wastes) ends up in sewage sludge. Sewage sludge is the product of any wastewater treatment processes, regardless of their origin (e.g., wastewater from municipal, agricultural or industrial activities) and is often incinerated or spread over land as a fertilizer. Knowledge of the mercury content in sewage sludge is important.

Hazardous Waste

The mercury content in the hazardous waste stream originates primarily from intentionally used mercury in discarded products and process waste. Some hazardous waste is incinerated as part of the treatment/disposal system. Hazardous waste refers to residues and wastes that contain hazardous materials in significant quantities. It is important to note that generally such waste with high concentrations of mercury should not be incinerated, and should preferably be sorted (if at all possible) and treated separately. Practically, however, this is not always possible. Therefore, when hazardous waste containing mercury must be incinerated, emissions controls should be in place as this could be a significant source of mercury releases.

What can governments do?

Regulatory measures that have been used successfully in different parts of the world include:

- Prevent or limit the intentional use of mercury in products and processes.
- Limit the allowable content of mercury present as impurities in high-volume materials (packaging, etc).
- Prohibit mercury in product waste and in process waste from being mixed with less hazardous waste in the general waste stream and being incinerated. Ensure separate collection and treatment.
- Set taxes and fees on hazardous waste disposal (special incineration, dedicated landfill, etc.) that fully reflect the real long-term costs to society and the environment of dealing responsibly with these hazardous substances.
- Put in place an environmental management strategy that includes responsible monitoring and enforcement of mercury regulations, tracking of all mercury movements (from raw material to process to product to waste), and periodic independent control.
- The existence of incineration emission legislation, while a necessary step towards significant incineration emission controls. However, alone, it is not sufficient to ensure compliance. A serious enforcement system must be in place as well where the authority not only has the power to enforce the relevant legislation adequately, but is also technically competent to understand the emission controls and measurement methods..
- Develop a facility for final disposal or containment of mercury (and other) treated wastes that cannot be responsibly disposed of in any other manner.

Useful educational measures could include:

- Educate the public about proper disposal of mercury containing products along with other hazardous waste.
- Provide collection points where the public may easily take these separated products.
- Devise several key indicators and publicize the progress that is being made with regard to responsible management of mercury.

NOTE TO DESIGNER: CASE STUDIES MAY BE PLACED THROUGHOUT DOCUMENT.

CASE STUDY: MASSACHUSETTS
Local and Regional Emission Reductions Lead to Reductions in Mercury Levels in Certain Fish

In the northeast part of Massachusetts, an area where several waste incinerators operate that were large sources of mercury emissions in the 1990's, close to 100% of the tested bodies of water had fish with elevated mercury levels. Mercury deposition modeling performed in 1998 demonstrated that this northeast part of Massachusetts was a mercury deposition "hotspot," with the highest rate of mercury atmospheric deposition in the New England region (NESCAUM, 1998).

In order to address the environmental, public health and economic impacts attributable to mercury pollution, the New England Governors and Eastern Canadian Premiers adopted a regional bi-national "virtual elimination" goal for anthropogenic mercury and a Mercury Action Plan in 1998. Massachusetts adopted a statewide Zero Mercury Strategy in 2000. These comprehensive plans were based on scientific and policy assessments that delineated the scope of mercury's impacts and established regional and state inventories of mercury sources. The plans established a long-range goal of virtually eliminating anthropogenic mercury pollution in the region and milestone reduction goals of 50% by 2003 and 75% by 2010.

Under these strategies, Massachusetts and the region as a whole have developed and are implementing some of the strongest programs to reduce mercury pollution and monitor environmental results in North America and perhaps the world. In Massachusetts programme elements include strict but achievable control requirements on the state's mercury sources. Regulations on trash incinerators, (Massachusetts and the region's largest source in 1998) took effect in 2000 and have reduced emisions from this category by more than 90%. Emissions from medical waste incinerators have been eliminated because health care facilities, facing stringent mercury and dioxin emission limits, shifted to alternative sterilization methods that do not emit significant amounts of mercury.

As a result of these and other comprehensive efforts, overall mercury emissions in Massachusetts have been reduced by about 70% statewide and by about 87% from sources located in the "hotspot" area noted previously. Emissions in many New England States are down by 60-70% and, regionally, by over 55%. Further reductions will occur as pending regulations (e.g., on coal burning utilities) are implemented.

Fish testing in the state has revealed substantial reductions of mercury levels in both of the freshwater species being evaluated. The most significant reductions were observed in the northeast part of Massachusetts, the "hotspot" area noted previously, where the largest reduction in mercury emissions has occurred. From 1999 through 2004 mercury concentrations in yellow perch from lakes in the "hotspot" area declined by an average of about 32%, and from lakes elsewhere in the state by about 15%. For largemouth bass the decline in the "hotspot" area averaged 24% and elsewhere in the state about 19%. These are encouraging results that suggest that local actions can result in relatively quick and significant improvements (http://mass.gov/dep/toxics/stypes/hgtrend.doc).

ACKNOWLEDGEMENT
This case study was provided by C. Mark Smith, Massachusetts Department of Environmental Protection Office of Research and Standards, Boston, Massachusetts.

CASE STUDY: INDIA
POLLUTION FROM THE PRODUCTION OF
MERCURY THERMOMETERS IN KODAIKANAL

In 1984 Ponds India Ltd. purchased a U.S. mercury thermometer factory and relocated it to Kodaikanal, Tamil Nadu State in India. Unilever acquired the plant in 1987. The plant imported most of its mercury from U.S. brokers and then distributed thermometers to markets in the U.S. and Europe. The factory closed in the spring of 2001, after local Greenpeace campaigners, citizens groups, and ex-plant workers revealed Hindustan Lever had dumped mercury and contaminated glass waste at a scrap yard in Kodaikanal, with the contents spilling onto the workspace, unbeknownst to the yard's barefoot workers (Greenpeace). The

workers suffered occupational health problems. Extremely high levels of mercury were also found outside the factory and deep inside the pristine Pambar Shola forests (Greenpeace, 2002).

In an unprecedented decision, the Tamil Nadu Pollution Control Board ordered the company to collect the mercury containing glass waste dumped in scrap yards and forests and send it back to the United States for recycling and disposal. Consequently, the company collected and sent 289 tons of waste material to a recycling facility in Pennsylvania in May 2003 (Greenpeace).

In September 2004, the Supreme Court Monitoring Committee ordered the company to clean the contaminated site and surrounding areas to “pristine levels”. The Tamil Nadu Pollution Control Board subsequently gave the company permission to dispose of equipment in the contaminated mercury factory with scrap dealers (Greenpeace, 2005).

RELEVANT LINKS
Basel Convention web-site: http://www.basel.int/

Draft Wisconsin Mercury Sourcebook
http://www.epa.gov/glnpo/bnsdocs/hgsbook/ed.pdf

INFORM:

Hg containing products and alternatives fact sheet
http://www.informinc.org/fsmercalts.pdf

Industrial switches, relays, etc.
http://www.informinc.org/fact_P3industrialmeters.php

Northeast Waste Management Officials' Association (NEWMOA)
http://www.newmoa.org/prevention/mercury/

UNEP (2005) Toolkit for identification and quantification of mercury releases
http://www.chem.unep.ch/mercury/Toolkit/UNEP-final-pilot-draft-toolkit-Dec05.pdf

UNEP (2006) Guide for Reducing Major Uses and Releases of Mercury.
www.chem.unep.ch/mercury/Sector Guide 2006.pdf

US EPA Environmentally Preferable Purchasing webpage
http://www.epa.gov/opptintr/epp/

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Allsopp, M., Costner, P., and Johnston, P. (2001) INCINERATION AND HUMAN HEALTH: State of Knowledge of the Impacts of Waste Incinerators on Human Health. Greenpeace Research Laboratories, http://archive.greenpeace.org/toxics/reports/euincin.pdf

Kurttio, P., J. Perkanen, G. Alfthan, M. Paunio, J.J.K. Jaakkola, and O.P. Heinonen (1998) Increased mercury exposure in inhabitants living in the vicinity of a hazardous waste incinerator. *Archives of Environmental Health* **53**(2) 129-138

NRC (2000) Waste Incineration and Public Health. Committee on Health Effects of Waste Incineration, Board on Environmental Studies and Toxicology. National Research Council.
http://newton.nap.edu/openbook.php?record_id=5803&page=1

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Acknowledgements:

Mercury Policy Project
Secretariat of the Basel Convention

Proposed Back Cover Page of each Module

Governments have agreed that there is sufficient evidence of significant adverse impacts from mercury and mercury compounds to warrant action on mercury. This publication was developed to raise awareness in certain countries and regions amongst stakeholders on the effects of mercury on human health and the environment. It is hoped that it will assist citizens, governments and health care workers to build support and the capacity to take action to reduce or eliminate mercury uses, release, and exposure to mercury.

This is one of six modules.

To find additional information on mercury and UNEP's mercury programme go to:
www.chem.unep.ch/mercury/

Note to Designer: Insert UNEP and Basel Convention logo on back.

Cover Page: Module 3

Mercury and Industry

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Key Messages

- Due to its unique chemical properties, mercury has been used in a wide range of industrial processes over the years, but currently most of it is used in:
  - Industrial processes that produce chlorine (mercury cell chlor-alkali plants), vinyl chloride monomer (for polyvinyl chloride (PVC) production, and polyurethane elastomers).
  - Artisanal and small scale gold mining (for more information on this, see Module 4).
- Trace amounts of mercury are found naturally in coal, oil and rock. Mercury is released unintentionally when coal is burned and metals are processed.
- Approximately 70% of man-made mercury releases to air comes from stationary combustion of fossil fuels,especially coal, and incineration of waste materials.
- Global mercury deposition has increased three times since the Industrial Revolution and regional and local deposition has increased up to ten times in some locations.
- Mercury emissions tend to be decreasing in North America and Europe. With the growth in economic prosperity, mercury emissions tend to be rising in Asia and Africa.
- Pollution control equipment is available to reduce mercury emissions from major air sources significantly.

WHY IS THIS IMPORTANT TO YOU?

- Facilities where mercury is used or released as a by-product can be major sources of mercury exposure for workers, surrounding communities, and the global community.
- Airborne mercury can be inhaled or deposited, leading to contaminated soil, water and fish.
- Local releases of mercury may lead to high local levels of mercury.

WHAT CAN YOU DO?

For the Public

- Be aware of industrial use and release of mercury in your area.
- Discarded mercury products and waste should never be burned, as the mercury will be released directly into the atmosphere.
- Governments can be asked to monitor major air sources to determine if pollution control equipment is needed to reduce mercury levels from local facilities.
- Governments can be asked to check mercury levels in local and imported fish and provide this information to the public.

For Governments

- Obtaining accurate mercury emission inventories are an important first step towards controlling major air sources of mercury. Understanding sources will make it easier to develop cost-effective emission control policies.
- Encourage industries and retailers to switch to mercury-free products and processes.
- Regulate and monitor industries using mercury.
- Establish national or regional safe containment facilities for mercury containing waste.

What industrial processes use and/or release mercury?

Intentional use of Mercury
Mercury continues to be used in a vast array of products (see module 2) and is released at different stages of manufacturing and use.

Mercury continues to be employed in some countries as a catalyst in certain industrial processes, to produce chlorine and caustic soda (in mercury-cell chlor-alkali plants), to produce vinyl chloride monomer which is used to make polyvinylchloride (PVC), and in the production of polyurethane foams.

Mercury is also used and released in artisanal and small-scale gold mining (this is covered in Module 4).

Unintentional Releases of Mercury
Certain activities emit mercury during combustion (coal combustion, local trash burning or larger-scale incineration) and in processing of mineral ores (industrial smelting) and aggregates (cement kilns).

Approximately 70% of anthropogenic mercury in the atmosphere comes from stationary combustion of fossil fuels (especially coal) and incineration of waste materials.

How does the mercury get released from industrial processes?

For intentional uses, mercury is released through:

- Emissions and wastes generated during the production of the mercury, (whether mined, by-product, recycled),used in the process (see primary mercury production case studies);
- Process releases, e.g., fugitive air emissions;
- Releases from trace or residual mercury in the products produced using a mercury process;
- Releases during the recycling of wastes;
- Release from wastes, sludge, residues, contaminated equipment and supplies produced during the process.

Older chlor-alkali and VCM production facilities (including those that have been closed for many years) are ty[pically sitting on heavily contaminated sites that continue to release mercuty into the local environment for years to come.

For unintentional releases, mercury is released via:

Coal Fired Power Plants
Mercury is present in the mined coal, from the weathering of volcanic rocks and the accumulation of mercury in ancient sediments. The mercury content of coal varies. Even the mercury content of coal from a specific country or region can be highly variable.

Although small quantities of mercury may be emitted while coal is stored and handled, most mercury is released from the combustion stack after it is burned. Boilers operate at temperatures above 1100ºC and mercury in the coal is vaporized and released as a gas. Some of the released mercury gas may cool and condense as it passes through the boiler and air pollution control device. The fraction of the mercury in coal that is not emitted to the atmosphere during combustion is trapped in wastes such as bottom ash and recoverable fly ash. It is important to note that the ash may be sent to landfill or may also be used in other products such as wallboard and cement.

> Note to Designer: This information could be in a separate text box.****
> In some regions of the world coal is used for home heating and cooking. This is not an industrial process, but it is noted here to highlight that in certain areas coal is burned in simple, sometimes unvented, household stoves, directly exposing people to emissions of mercury, and/or other toxic

substances and organic compounds. While the use of coal for these purposes is gradually decreasing as incomes rise and alternative fuels become available, there remain hundreds of millions of people who continue to be exposed to a range of risks from such practices. There are ways to reduce the mercury exposure of people who burn coal domestically. These include better ventilation, modified cooking/heating stoves, fuel switching, use of low-mercury coal.
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Industrial Smelting

Mercury is produced as a byproduct of processing ore in mining. Metal is generally extracted from the ore by heating it to a temperature that releases the metal. As mercury has a lower boiling point than many other metals (such as copper, silver, lead, zinc and gold), the mercury is often released as a gas during the smelting process. Unless the mercury is captured by process equipment dedicated to this purpose, much of it will be released to the atmosphere and aquatic environments, and some disposed of to land. In some ores the concentration of mercury is high enough to make recovery for sale economical.

There are a large number of small-scale, artisanal smelting operations worldwide. Most do not have controls in place to prevent or control mercury emissions from their operations. In such cases workers generally have very basic tools and little in the way of personal protective equipment. Reportedly, some of the villagers who are involved in smelting have symptoms suggesting mercury exposure (GVB, 2006). Certain aspects related to this are considered in Module 4 on artisanal and small-scale gold mining.

Cement Production

The raw materials used for the production of cement contain trace concentrations of mercury. Mercury originates from three basic sources: naturally present in virgin raw materials (lime, coal, oil, etc.), in solid residues from other sectors (e.g., fly-ashes and gypsum from combustion of coal) often used as raw materials for cement production, and in wastes sometimes used as fuels in cement manufacturing. The last two sources may significantly increase the total input of mercury to cement production, depending on materials.

Cement production is a good example of a source of mercury releases due to the use of materials with very low mercury concentrations, but consumed in very great quantities. The major pathway for mercury releases from cement production is to the air, and to a lesser extent to the soil, in wastes and residues, as well as in the cement product itself.

Incineration

Mercury is also released from waste incineration. See Module 2.

What are the risks?
For certain facilities, occupational exposures may be expected, although actual exposures to mercury might be less of a concern than a range of other pollutants that workers would likely be exposed to, such as dust, gases, lead and cadmium.

Impacts on people living near operations result primarily from atmospheric emissions and sometimes effects related to leaching of mercury from residues (such as in some smelting operations).

Two key issues that local residents may be concerned about are mercury deposition and fish contamination in their area. For example, with regard to local deposition, it has been demonstrated that the most bioavailable mercury releases from coal-fired boilers fall closest to the source of emissions. Power plants can contribute about 30% of the locally deposited mercury. Hotspots with high mercury levels have been identified where multiple local sources contribute more mercury than regional and global sources. Other sources of mercury, including naturally-occurring sources, can also raise background levels above those generally found. In some cases, fish consumption advisories may be needed.

Artisanal smelting must be assumed to have severe health effects on those doing the smelting, as well as significant hazards for those living in the general vicinity, perhaps up to one kilometer away, depending on the prevailing wind direction. Likewise, leaching of mercury to local water supplies, fish, other food sources, and downstream users could have significant health impacts.

Is it possible to reduce mercury releases from existing facilities that use and/or release mercury?
Many steps can be taken at existing facilities, in addition to "good housekeeping" measures and "best management practices", to reduce mercury use and emissions for all sources.

The most effective method for controlling mercury emissions is to avoid using raw materials containing mercury. However, this may increase production costs and may not be economically feasible. For releases to the atmosphere, the height of the emission stack and velocity speed at which flue gases enter the atmosphere influence the distance the mercury travels before deposition. Likewise, the atmospheric chemistry present at the height of release, and the potential for reactivity over distance, may influence eventual exposures.

A useful starting resource in providing guidance on reducing mercury releases is the 'Guide for Reducing Major Uses and Releases of Mercury' UNEP 2006. This document is available at the following web address: http://www.chem.unep.ch/mercury/Guidance-training-materials.htm .

- The Basel Convention on the Control of Transboundary Wastes and their Disposal has developed relevant technical guidelines on environmentally sound management of waste that are a good starting point in addressing hazardous waste such as mercury. The following web-link provides a link to a number of Basel Convention technical guidelines: http://www.basel.int/meetings/sbc/workdoc/techdocs.html
-

What are the barriers to adoption of mercury-free processes?
Most of the resistance to change in industry is due to the cost (real or perceived) of switching to a mercury-free alternative. This is especially the case of mercury used in chlor-alkali production, and mercury catalyst used in the production of VCM and PVC. From the industry perspective, the costs of conversion include not only investment in research and new equipment, but also the cost of production down-time, the cost of cleaning up previous soil and groundwater contamination on site, the cost of disposing of all contaminated equipment and construction materials, etc.. It is not surprising that many of these industries put off conversion as long as possible.

In some cases (chlor-alkali production) the mercury free membrane process is less expensive to operate once it is installed. In others (VCM), the non-mercury process is significantly more expensive because it does not

rely to the same extent on inexpensive local resources of coal. In the case of VCM, market forces are driving VCM production to countries where there is limited regulation associated with mercury and/or this particular production process.

What can governments do?
The development of a mercury use and emission inventory is a good first step in assessing the scope of the problem at the national or regional level. UNEP has developed the 'Toolkit for identification and quantification of mercury releases' to assist countries in undertaking such work. The toolkit is available at the following web address: http://www.chem.unep.ch/mercury/Toolkit/default.htm

Substituting processes without mercury for processes with mercury is one of the most powerful preventive measures for influencing the entire flow of mercury through the economy and environment. Governments must consider the social perspective, the human health and environmental impacts of industrial activities of mercury as well as economic factors such as employment in decision-making.

Pollution control measures should consider a wide range of pollutants including mercury, particularly when considering the construction of new facilities.

Certain regulatory measures that may be considered include:

- Requiring that any mercury contained in process wastes be recovered, such as in the chlor-alkali industry.
- Prohibiting or restricting cross-border transport of mercury and other hazardous wastes.
- Requiring that any mercury containing waste or materials stored on-site by an industry or commercial operation must be in air-tight and waterproof containers, and that the organization must have complete records, and a written plan and schedule for proper disposal of the materials. See Surplus Mercury Management section below.
- Requiring industries using mercury to prepare a mercury balance each year showing how much mercury entered the process and how much was emitted.
- Prohibiting the disposal on land of any sewage sludge, fertilizer or other material that exceeds responsible international standards for mercury content.
- Putting in place an environmental management strategy that includes responsible monitoring and enforcement of mercury regulations, tracking of all mercury movements (from raw material to process to product to waste), and periodic independent assessment.

Technical measures for dealing with mercury wastes may be divided into pre-treatment measures and emission control measures. Pre-treatment measures may include prohibiting or limiting mercury releases to the environment by separating mercury and mercury-containing items from household waste, hazardous waste and medical waste. Emission control measures could include:

- Preventing or limiting mercury from industrial processes (such as chlor-alkali and metallurgic industry) from being released directly to the environment
- Applying emission control technologies to limit emissions of mercury from combustion of fossil fuels and processing of mineral materials
- Preventing or limiting the release of mercury from processes to the wastewater treatment system
- Preventing or limiting the use of obsolete technology and/or requiring the use of the best available technology to reduce or prevent mercury releases.

Surplus Mercury Management (note to designer: could be a text box)

A surplus mercury management facility is designed to prevent mercury release to the environment and exposure risks to humans. There should be a well-ventilated, designated location for the storage of waste mercury collection drums. These steel drums must have liners and be placed on a concrete slab. Drums must be protected from rainfall and secured from theft and/or to protect against unauthorized opening. Broken and/or obsolete mercury

medical devices may be placed in these drums along with mercury from clean-up operations (following facility mercury spill clean-up procedures). Such facilities should develop a waste mercury collection plan including procedures and outlining responsibilities. Before beginning there be an established schedule for when the mercury will be removed for processing, proper management and disposal.

What can companies using mercury in their processes do?

It is very important for a company to have a good working relationship with its employees and the local community. If the relationship is good, problems can be more easily resolved, and the local community will be more inclined to trust the proposals and actions of the company.

As a start, any company that uses mercury in its operations should have a specific written plan for dealing with mercury. This plan ought not only to demonstrate compliance with all government regulations, but cover all of the issues listed below, together with deadlines or milestones for taking certain specific actions or meeting environmental standards, as necessary. In general, the management plan should promote ongoing reductions in mercury uses, releases, trade, and human exposure to mercury. At the same time it should also include emergency management procedures, such as how to deal with mercury spills and with workers who have been exposed to high levels of mercury.

The company must determine what occupational exposures to mercury may be experienced by workers. It should have a program for monitoring air concentrations of mercury in the workplace, worker exposures and for dealing quickly with any evidence of harmful exposure. It should also have a plan for ongoing reduction and, if possible, eventual elimination of occupational exposures through changeovers to mercury-free products and processes.

Each company should have a fair idea, at any time, of the quantity of mercury used and released through its practices and products. It should be aware that releases may vary significantly depending on the production or process activity rate, the raw materials used, the age and maintenance of equipment, and even the ambient weather conditions.

The factory management should also be generally aware of where its emissions are going – what part of its emissions into the upper atmosphere and deposited far away, what part into the local atmosphere and deposited locally, the direction of the prevailing winds, emissions to wastewater, etc. It is only in such a way that a company can have a reasonable idea of the possible impact of its mercury emissions on the local population and the environment.

Whatever the circumstances, the company also requires a program for ongoing reduction of mercury emissions, possibly linked to the level of production, with milestones and target dates and annual reviews of its mercury monitoring and reduction strategies.

The company should have a good understanding of its mercury waste situation. How much mercury waste is generated, what type of waste (sludges, filtercake, tailings, ash, slag, etc.) is generated, what is the approximate mercury content of the different types of waste, under what conditions may waste be stored? Furthermore, in order to manage mercury wastes adequately, the company has to know precisely where and how its mercury wastes are disposed of. For example, due to the known risks of mercury on human health and the environment, it is no longer acceptable merely to transfer mercury wastes to another person or company and blissfully to forget about them. Are the mercury wastes going to a landfill, and if so, is it a municipal landfill or a special landfill? What is the chance that these mercury wastes may be burned on the landfill or elsewhere? What is the risk of mercury exposure to people who may be scouring a waste dump in search of reusable materials?

If the mercury waste is treated, what kind of treatment is used, and how is the waste disposed of after treatment? Is final disposal deep underground and no longer a concern, or is it possible that mercury wastes may still be burned or incinerated? With mercury emissions, the company ought to have a mercury (and

other) waste reduction program that targets ongoing decrease of the volume and mercury content of wastes, as well as gradually improving treatment and disposal practices which meet gradually higher standards.

While some improvements referred to here be obvious, other measures that may be implemented to achieve ongoing reductions in mercury occupational exposures, emissions and wastes are not always evident. There are increasing resources available to assist the company to move in this direction, such as:

UNEP (2005) Toolkit for identification and quantification of mercury releases
http://www.chem.unep.ch/mercury/Toolkit/UNEP-final-pilot-draft-toolkit-Dec05.pdf

UNEP (2006) Guide for Reducing Major Uses and Releases of Mercury.
www.chem.unep.ch/mercury/Sector Guide 2006.pdf

There is often a general concern that improvements of various types designed to reduce mercury releases will be prohibitively expensive. While this is certainly true in some cases, there are frequently a great number of measures that may be taken for very little or no cost. Employees may be very happy to help out in various ways when they know that such measures can reduce mercury exposure to themselves or their community. Furthermore, the reduction or elimination of mercury or mercury wastes has often been shown to save money for a company because it no longer has to devote funds to filter flue gases or wastewater leaving the building. The firm can also economize on costly mercury waste disposal.

NOTE TO Designer: Case Study may be placed where appropriate in the module.

CASE STUDIES: Primary Mercury Production

Primary Mercury Mining

It appears that primary mercury mining is decreasing. However, in Kyrgyzstan primary mercury mining for export continues, and China continues primary mining for domestic use.

In July 2006 two Global Village of Beijing (GVB) members went to Tongren, Guizhou Province for an environmental investigation. The specific targeted areas included Tongren City and Wanshan Special District. The focus of this investigation was on mercury mining, smelting, trade and other current conditions and historical effects related to mercury.
Over 40 years of mining has led to serious geological damage and geological disaster risk in the investigated area. Some small-scale disasters have already occurred. The local government has plans to move the village away from the high-risk area of Tongren.

Huge amounts of tailings form no fewer than 10 hills surrounding the mining areas, which cover natural habitats and agricultural land. Mercury in different forms is washed away to downstream rivers and lakes, and also enters into soil and groundwater. It will take decades to clean up these tailings, depending on various factors such as financial assistance and appropriate technology.

Local villagers are continuing to look for mercury ore from exhausted mines and tailings, though the mercury content in these ores is very low. Investigators visited an authorized small-scale mercury mine, with estimated reserves of 2000 tonnes. Many of these ores will be sold to artisanal mercury smelters located nearby.

Investigators visited two centralized artisanal mercury smelting spots. One is larger, with nearly 200 stoves, while the other one is smaller, with only around 20 stoves. The two spots smelt different materials to produce mercury. The larger one is located near the small-scale mercury mine mentioned above and thus smelts mercury ores. The smaller one smelts depleted mercury-containing catalyst purchased from PVC plants. There are several similarities between the two spots. They are both run by local villagers and use the same primitive smelting equipment, which are not well leak-proofed. Workers have few tools and are all not protected well. Although the health effect has not been studied, one young person said that some of the villagers who are involved in smelting show abnormal symptoms. It is very hard to quantify their resource input and product output because both the ores and waste catalyst come in irregularly and the production rate varies significantly.

Source: Executive Finding of Mercury Investigation in Guizhou, Global Village of Beijing, 2006

CASE STUDY: SOUTH AFRICA
MERCURY PRODUCTION: PROBLEMS IN A MERCURY PRODUCTION FACILITY

In the 1970s Thor Chemicals operated a mercury-production facility at Margate, Kent, England. When excessive levels of mercury were found in the air and in workers' urine in the 1980s, the Health and Safety Executive of Great Britain threatened prosecution. Thor closed the Kent plant in 1987 and relocated to Cato Ridge, South Africa, a small, industrial village in the self-governing province of Kwazulu-Natal. The facility at Cato Ridge was to be a mercury reclamation operation and it began accepting mercury waste from the U.S. and UK, ostensibly for treatment and recovery. The mercury shipped to Thor SA contained 30-45 percent organic content, a level generally not accepted in the U.S. or Europe (Earthlife, 1994). The unskilled Zulu-speaking labor force employed at Cato Ridge was not trained in the dangers of occupational exposure to mercury.

Tests conducted as early as 1988 showed that nearby rivers and streams (drinking water sources)– had mercury levels greater than WHO recommendations (UMich, 2001). The Environment Ministry announced in 1990 that South Africa would no longer import hazardous wastes (Ward, 2002). Nevertheless between 1991 and 1994, three U.S. companies shipped over 2500 drums of mercury waste to South Africa, without notifying the U.S. of these exports, as required under the U.S. Resource Conservation Recovery Act (Greenpeace, 1999). Borden Chemicals eventually recalled 150 drums under intense international scrutiny from environmentalists (UMich, 2001).

In 1990 Earthlife Africa received reports of Thor workers "going mad" (UMich, 2001). A doctor from the Industrial Health Unit (IHU) diagnosed mercury poisoning in four workers and further investigation revealed that 87% of workers had mercury levels that were above the safe limit (Butler, 1997). By 1992 two Thor workers had died of mercury poisoning, and an IHU study revealed that almost 30% were in danger of permanent health damage from it (UMich, 2001). The families of the deceased workers sued Thor in a British court and were awarded almost US$2 million. Compensation for injured workers, however, has been much smaller and barely sufficient to cover their medical expenses (Lipman, 2002).

In fact, Thor had not been processing the mercury waste at all but merely storing it. In 1994 a visit to the site by delegates from the African National Congress uncovered a sludge pond brimming with 2500 tonnes of mercury, and three warehouses overflowing with more than 10,000 rusting and leaking barrels of mercury waste (Earthlife, 1994). While Thor officials contend the process designed to capture mercury turned out to be flawed, environmentalists say the treatment never existed and that Thor never intended to do anything other than store and incinerate the waste-mercury (Greenpeace, 2002).

The discovery of catastrophic contamination levels around the plant convinced the Department of National Health to close Thor's recovery plant and incinerator in 1994, but thousands of tonnes of stockpiled waste remained on the site in leaking barrels and Thor was allowed to continue producing mercury catalysts until 1999 (Njobeni, 2004).

The Davis Commission of Inquiry was appointed (Naidoo, 2003) in 1995 and produced a report in 1997 proposing that waste be disposed of through incineration. Environmental groups opposed this solution and called on the companies that originally exported the waste to South Africa to reclaim it (Lipman, 2002). The incineration proposal was eventually rejected because of an inability to work out a cost-sharing agreement between the South African government and Thor.

In 2002 the South African government reopened the issue through environmental legislation. In March 2003 after failed attempts to get Thor to clean up the 8000 tons of mercury waste at Cato Ridge, the Deputy Minister of Environmental Affairs issued a Directive ordering Thor to clean up or face legal action in accordance with the National Environmental Management Act (Groundwork, 2003). After lengthy negotiations, Thor finally agreed to contribute US$3 million towards the clean-up and the South African government agreed to contribute US$300,000 towards the payment of Project Engineers to design and oversee the operation (SA, 2004). The combined amount is only sufficient to cover the first phase of the project, as total costs are estimated to be US$9 million (Naidoo, 2003).

The first phase of the clean-up, launched in August 2004, involved a waste categorization process, followed by an assessment of the impact of different methods of disposal (SA, 2004). Disposal options include: thermal retorting; disposing of waste at an appropriate disposal facility; sending the waste back to the producer and country of origin; transporting the waste to another country with adequate disposal facilities; and/or collecting the waste from warehouses, contaminated soil and buildings and storing it safely on site (Peek, 2004). The Davis Commission also plans to investigate how the Thor incident was allowed to happen and how legislation could be developed to ensure that it does not occur again.

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CASE STUDY: AZERBAIJAN
THE STORAGE OF MERCURY WASTES

Industrial enterprises, particularly the oil and gas mining industry, energy generation and transport sectors, are the main sources of pollution in Azerbaijanian cities such as Baku and Sumgait. The use of outdated technologies and equipment, along with insufficient pollution reduction measures, result in high local and regional contamination from mercury and other toxic substances.

The most serious problem in Sumgait is mercury pollution from two mercury-cell chlor-alkali plants. One of these stopped production in 1981, but the other continues to operate. Mercury loss in chlorine production there was at one time 1 kg per tonne of chlorine produced, although it has since decreased to 300 g/tonne. With up-to-date processes, this figure could be as low as 2-3 g/tonne.

Mercury released from the chlorine production process has been emitted to the atmosphere, released in wastewater and collected in solid waste. About 200,000 tonnes of slime containing 0.1% to 0.3% mercury has been collected before it flowed into the Caspian Sea. However, refined wastewater released into the Sumgait River has resulted in a high level of mercury contamination there. Initial research has shown that mercury has collected in the marine ecosystem and that the methylmercury levels in fish in the area could exceed safe limits. Treatment of the slime there has not been possible due to the lack of highly efficient clean-up technology, complex local geology and the proximity of the area to the water table and the Caspian Sea. The lack of infrastructure and funding has hampered proposed clean-up projects. Future use of this land will require a highly efficient soil clean-up method.

To prevent deterioration of the situation, the World Bank suggested halting chlor-alkali production and isolating the mercury-containing waste. A "Hazardous Waste Containment Area" for permanent burial of toxic wastes was built near Sumgait on the Absheron peninsula in July 2004. This area has been constructed in accordance with the international standards and is registered with the Ministry of Justice. It includes a 250,000 m^2 pit, isolated from the surrounding environment with a geomembrane polymer barrier. The current project includes cleaning up certain areas of the plant located in Sumgait and disposing of wastes from those areas at the containment area. So far, 40,000 m^3 of mercury-containing waste (slime) has been disposed of there. Future expansion of the area is planned. This is the first hazardous waste containment area in Azerbaijan and is considered a good precedent for future efforts to contain other types of toxic waste currently stored at industrial sites.

A similar containment scheme may be considered for mercury-containing lamps. There are currently about 1,000,000 to 1,500,000 spoiled mercury-containing lamps in Azerbaijan. Currently the lamps are taken to landfills (sometimes even unofficial landfills), where they are broken and the mercury enters the soil. Procedures for phasing out the use of such lamps and controlling their disposal have not yet been fully applied due to the cost.

ACKNOWLEDGEMENT
The authors gratefully acknowledge Issa Aliyev, Adviser to the International Cooperation Department of the Minister of Ecology and Natural Resources in the Republic of Azerbaijan for this case study.

The picture is good and relates to above, but not a must.

Figure 3-1. Hazardous Waste Containment Area in Azerbaijan
The white areas are strips of a plastic coating called a geo-membrane isolation layer that contains the hazardous waste. The plastic coating is held together at the seams to make it tighter and to prevent percolation.

CASE STUDY: CZECH REPUBLIC
MERCURY CONTAMINATION FROM A CHLOR ALKALI FACILITY

Mercury levels in soil, air, water and fish are dangerously high in the area surrounding the Spolana chemical plant near a town of 16,400 inhabitants in the Central Bohemian Region of the Czech Republic.

The Spolana plant is one of two chloralkali plants in the Czech Republic that are using the mercury cell chlor alkali process to produce chlorine. The factory is scheduled to begin using a non-mercury membrane technology by 2015. Meanwhile, significant quantities of mercury continue to be used—and released -- each year (Kuncová, 2004a). Between 1994 and 2003, Spolana Neratovice produced over 700 tonnes of mercury-containing waste, which the company disposed of in its own hazardous waste landfill (Kuncová, 2004b). During the eight years of operation between 1996 and 2003, more than one tonne of mercury was released into the air (Kuncová, 2004b). In the ambient air in the vicinity of the new plant, concentrations of mercury ranging from 50 to more than 150 ng/m^3 were detected (Kuncová, 2006).

At the Spolana site there is also an older mercury cell operation which was closed in 1975. It has not been maintained since that time and is another major source of mercury contamination (Kuncová, 2004a). Although mercury has not been used for 30 years in the old plant, mercury concentrations of more than 950 ng/m^3 were detected in the ambient air at that site (Kuncová, 2006).

In 2003 mercury concentrations were measured around both new and old facilities using a Lumex RA-915+ air analyzer. Buildings, the soil, groundwater and surface water at the old chemical plant are contaminated. The quantity of mercury in soil and construction materials is estimated to be 264 tonnes. The concentrations of mercury in the soils in the vicinity of the old plant were more than 175 mg/kg and more than 400 mg/kg in the vicinity of the operational plant.

In 2003 the State Veterinary Institute analyzed seven freshwater fish from the nearby water basin where mercury concentrations ranged from 0.124-0.711 mg/kg – seven times higher than the limit allowed for freshwater fish. They were identified as not fit for consumption. The highest concentrations of mercury were found in fish caught downstream from Spolana.

In 2004 the Czech State Health Institute analyzed the mercury content of the blood, hair and urine in residents of the community. Blood mercury concentrations in residents living near the chloralkali plant were twice as great as levels in a control group and in the rest of the Czech Republic population. The symptoms most frequently identified were all related to the nervous system, typical of mercury exposure (Kuncová, 2004b).

An Environmental Impact Assessment for Spolana and a decontamination process were prepared and agreed upon in 2004. The clean-up method will include encapsulating the mercury, demolishing the buildings, and removing the surface layer of soil. The waste will go to a thermal desorption process to remove mercury and then the clean waste will go to the landfill. The costs are estimated to reach more than $US 20 million.

ACKNOWLEDGEMENT -- This case study was provided by Hana Kuncova of Arnika Association, Toxicke latky a odpady. Chlumova 17, 130 00 Praha 3, Cesk· republika, tel./fax: (+420) 222 781 471, e-mail: hana.kuncova@arnika.org

Useful Links:

Euro Chlor website: http://www.eurochlor.org

IEA Clean Coal Centre web-site: http://www.iea-coal.org.uk/site/ieacoal/home

UNEP Toolkit for identification and quantification of mercury releases:
http://www.chem.unep.ch/mercury/Toolkit/default.htm

UNEP (2006) Guide for Reducing Major Uses and Releases of Mercury.
www.chem.unep.ch/mercury/Sector Guide 2006.pdf

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Acknowledgements:
Mercury Policy Project

Proposed Back Cover Page of each Module

Governments have agreed that there is sufficient evidence of significant adverse impacts from mercury and mercury compounds to warrant action on mercury. This publication was developed to raise awareness in certain countries and regions amongst stakeholders on the effects of mercury on human health and the environment. It is hoped that it will assist citizens, governments and health care workers to build support and the capacity to take action to reduce or eliminate mercury uses, release, and exposure to mercury.

This is one of six modules.

To find additional information on mercury and UNEP's mercury programme go to:
www.chem.unep.ch/mercury/

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Cover Page: Module 4

Mercury Use in Artisanal and Small Scale Gold Mining

NOTE TO DESIGNER:
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NOTE TO THOSE REVIEWING:
The target audience for this is those who can make a difference in changing behaviour in the mining communities, such as governments, health care workers and citizens. This is not a training manual.

KEY MESSAGES

- Artisanal and small scale gold mining (ASM) provides an important source of income for miners, particularly in rural communities and regions where economic alternatives are extremely limited. With gold rising from $260 US/oz in March 2001 to $760 US/oz in October 2007, a gold rush involving poverty-driven miners is currently being observed in many countries. The number of miners using mercury may increase in the coming years.
- Artisanal and small scale-gold mining involves an estimated 10-15 million miners, including 4.5 million women and 1 million children.
- ASM is the single largest intentional-release of mercury in the world, one that:
  - Results in severe exposure to workers, releases to the environment and poses risks to those in the nearby community who eat fish contaminated with mercury. Women of child-bearing age and children are most vulnerable.
  - Results in extensive environmental degradation and ecosystem contamination, which may go on for decades after mining activities have ceased.
- Mercury exposure for miners and their communities can be reduced in simple and cost-effective ways.
- Cyanide, the only chemical extraction alternative, also presents risks to human health and the environment.

WHY IS THIS IMPORTANT TO YOU?

- Artisanal or small-scale gold miners who use mercury are often unaware of its dangers.
- Miners, their families and communities, and those downstream are at risk of mercury poisoning.
- Serious long-term environmental health hazards exist in populations living in, near or downstream/wind of mining operations.
- Storage, transport and handling of mercury introduces opportunities for spills and exposure to mercury vapour.

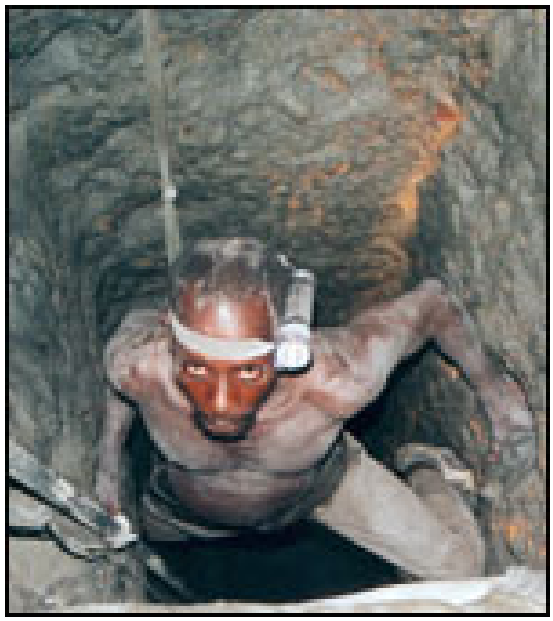
WHAT CAN YOU DO?

For Citizens	For Health Care Workers	For Governments
• Be aware that mercury use is dangerous for miners, their families and the surrounding community. Do not consume fish from areas downstream of mining. • Never use mercury and cyanide in the same area. • Make sure mercury is stored and used far away from families and children.	• Recognize the symptoms of mercury poisoning (see Module 1) • Educate people in mining communities about the dangers of mercury. • Inform authorities when mercury poisoning is found, so that other people in the area can be examined and the source of the mercury contamination identified.	• Identify where mercury is being used in ASM and take steps to educate miners and communities. • Encourage miners to reduce mercury use and to reduce releases through use of retorts. • Identify areas with low mercury level fish. Advise people to reduce consumption of large predatory or carnivorous fish that are likely to have higher mercury levels. • Take steps to limit mercury supply. • Build community capacity to market ‘Green Gold’.

What is artisanal and small-scale gold mining?
Artisanal and small-scale gold mining (ASGM) is the extraction of minerals, most commonly gold, by miners working in small or medium sized operations, using rudimentary techniques. Simple practices with little economic investment are often used. Mercury is often used to separate the metal from the ore and is generally handled by people with little or no awareness of its risks, training to minimize risks, or safety equipment.

ASGM provides an important source of income for miners, particularly in rural communities and regions where economic alternatives are extremely limited. At least 100 million people in over 55 countries depend on ASGM for their income. ASGM produces 20-30% of the world's gold, or approximately 500-800 tonnes per annum.

Figure 4-1. Maxwell Adzoka descends into his shaft at I Trust My Legs, an illegal mining camp (where 3000 miners work) along a gray stream in Ghana, where small-scale mining has been a respected tradition for centuries.
Photo by Josh Harkinson



Where is mercury used in ASGM practices?
Mercury use in ASGM is prevalent in China, Indonesia, Brazil, Bolivia, Colombia, Ecuador, Ghana, Peru, Philippines, Venezuela, Tanzania, Zimbabwe and other countries. Mercury may be used in at least 50 other countries to varying degrees. See diagram below.

Angola, Belize, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Cambodia, Cameroon, Central African Republic, Chad, Chile, China, Columbia, Congo, Costa Rica, Cote d'Ivoire, Dominican Republic, DRC, Ecuador, El Salvador, Ethiopie, Gabon, Gambia, Ghana, Guatemala, Guinea, Guinea Bissau, Guyana, Honduras, Indonesia, Kenya, Lao PDR, Liberia, Madagascar, Malaysia, Malawi, Mali, Mexico, Mongolia, Mozambique, Namibia, Nicaragua, Niger, Nigeria, Panama, Papua New Guinea, Peru, Philippines, Rwanda, Senegal, Sierra- Leone, South Africa, Sudan, Suriname, Swaziland, Tanzania, Togo, Uganda, Venezuela, Vietnam, Zambia, and Zimbabwe.

NOTE TO DESIGNER:
Diagram is attached separately as it seems to slow down the document considerably.

In many countries the use of mercury is discouraged or even prohibited for use in gold mining. Nevertheless, mercury use is generally prevalent and is the preferred method of extraction employed in ASGM as it is simple to use and inexpensive.

Mercury demand in ASGM continues to increase, particularly due to the rise in the price of gold. In general, large-scale gold mine operations have phased out mercury use by adopting alternative technologies.

How is mercury used in ASGM?

Mercury is used to separate and collect the gold from the rocks in which it is found. Mercury binds to the gold to form an amalgam which helps it to separate from rock, sand or other material. The amalgam is then heated to vaporize the mercury leaving the gold behind. A number of different techniques are used which result in varying degrees of mercury release:

Whole Ore Amalgamation

In this process mercury is added to all of the ore being processed during crushing, grinding or sluicing. This is the most polluting way to use mercury. In many cases only 10% of the mercury added to an amalgamating barrel or pan (in the case of manual amalgamation) combines with gold to produce the amalgam. The rest (90%) is excess and must be removed and recycled or is released to the environment.

Whole ore amalgamation leads to widespread elevated mercury levels in the local environment and the most severe health exposure problems for both miners and non-miners. Studies conducted in locations where whole ore amalgamation is practiced show the highest levels of mercury in soil, sediments and fish.

Gravity Concentration or "Panning"

Panning (gravity concentration) of gold-bearing materials is a common process. This concentrates the gold with the heavier particles in the pan, while lighter particles are sluiced away. Mercury is then added to the concentrates in order to amalgamate or gather the fine gold particles. This process is an improvement over whole ore amalgamation. About 10-15% of mercury losses from ASGM are a result of this process.

Burning Amalgam

Miners also heat amalgam to recover the gold. Amalgam is burned in a shovel or metal pan over an open fire. When this is done without the use of a retort, mercury vapours are released to the air and are inhaled by the miners, their families and others nearby. Retorts can collect the mercury vapour, preventing release to the atmosphere and reducing the human health risk to the miners, their families and communities. This practice produces atmospheric mercury emissions of around 300 metric tonnes per year worldwide (GMP, 2006). Retorts are a relatively simple technology which can recover much of the mercury vaporized from the amalgam.

> **What is a retort?**
> **NOTE TO DESIGNER… This could be a text box and diagram.**
> A retort is essentially a bowl or other vessel inverted over the burning amalgam in which the mercury vapour is trapped and condensed. The United Nations Industrial Development Organization's Global Mercury Project field assessments found that effective retorts could be made cheaply (e.g., for as little as $3.20 US, in some cases) and that they could retain mercury vapor so that over 95% of the mercury is recycled and can be re-used. This practice reduces exposure hazards and saves money. There are many types of retorts. Some are made of stainless steel, while others are made of inexpensive galvanized steel. The retorting efficiency depends on the type of connections or clamps used. Homemade retorts can also be made of steel tins or kitchen bowls (e.g., stainless steel or enamel bowls). The amalgam is heated with wood, charcoal or an electric element, and mercury vapors condense on the cover-bucket walls.

How are people exposed to mercury in ASGM?

The major pathway of concern for the miner is through the inhalation of mercury vapor from burning mercury amalgam. Some mercury is also absorbed directly through the skin when amalgamation is done by hand. Typically, amalgamation and burning are done with no protective measures (i.e., retorts or gloves) and often in the presence of children or even in the home.

Mercury vapour also settles in homes and onto food preparation areas and soil, and into local bodies of water. Mercury vapor is a danger not only to the local population, but can be carried long distances in the atmosphere. Eventually it is deposited and is taken up in bacteria in aquatic environments and converted from elemental mercury into methylmercury. Methylmercury bioaccumulates in the food chain and is the primary source of mercury in our food (see Module 1).

Even in low doses, methylmercury poisoning causes neurological problems and is especially dangerous for women of child-bearing age (see Module 1). With extremely high mercury concentrations found in breast-milk of nursing mothers in ASGM communities, infants are especially at risk.

Mercury dust is also carried on the clothing of miners and brought back to their homes in this manner.

Health surveys across ASGM sites worldwide show high levels of mercury in miners. Some miners are being exposed to levels of mercury that exceed more than 50 times the World Health Organization (WHO) public exposure limit. At one project site almost 50 percent of miners experienced unintentional tremors, which is a typical symptom of mercury-induced damage of the central nervous system.

How does mercury use in ASGM affect the environment?

Sites identified with high concentrations of metallic mercury, usually in or near flowing water, are called mining "hotspots." Hotspots can have dimensions of a few square meters to hundreds of square meters. They are major sources of mercury dispersion into aquatic systems, resulting in methylmercury contamination of fish and wildlife and impacting the lives of thousands of people involved with, or living in general proximity to, mining activities. Typically mercury-containing tailings are dumped into or beside bodies of water, and as a result soil, rivers, streams, ponds and lakes are contaminated for very long periods of time. There are thousands of polluted sites that will be affected for decades to come, and their impacts extend beyond the local area, often presenting serious, long-term environmental health hazards to populations living downstream of mining regions. One particular danger comes with the disintegration of tailing dams due to floods or severe weather. This results in high quantities of mercury-laden sediment being washed downstream. A related danger comes from the combined use of mercury with cyanidation - this is a very hazardous combination as it promotes the methylation of mercury.

How can mining communities minimize mercury use and exposure?

Although the use of mercury is generally an easy and inexpensive way to extract gold in ASM, cost-effective alternative methods exist that can eliminate or greatly reduce the quantity of mercury used, thus reducing health and environment risks and saving the additional expense of using excess mercury.

Alternatives to whole ore amalgamation

Amalgamation of the whole ore is an easy and inexpensive way to extract gold quickly for miners. The key is to concentrate the gold-containing portion of the ore before adding mercury. This can be done by crushing and grinding the ore to a finer particle size and then using carpeted or magnetic sluice boxes or gravity concentration techniques such as panning or centrifuges. In this way, more gold will be captured, less mercury will be required, and residual mercury can be more completely captured.

Protective measures

Protective measures include the use of retorts when burning amalgam (which not only conserves mercury and makes it available for reuse, but protects workers and their communities) and the use of gloves by those handling mercury or amalgam.

Alternatives to mercury use

A complete phase-out of mercury use in mining may be a viable option for many miners. However, this might require a higher order of economic investment, organization, and technical expertise. Primary ores must be ground to promote gold particle liberation. Free or partially free gold particles can be concentrated. Miners need to know how finely to grind the ore, and whether another treatment, like oxidation, is needed.

Gravity separation or concentration methods (e.g., carpet sluices, magnet-based methods and centrifuges) have great potential to reduce and, in some specific situations, to eliminate the use of mercury. In approximately 10% of current ASM cases, gold sources are alluvial ore (free gold), and completely mercury-free-alternatives could be locally available at a very low cost.

The most promising technology to replace totally the use of mercury in any type of gold ore is cyanidation, but this method may not be affordable or technically available to all artisanal miners. Also, cyanidation methods must be used with care and carefully introduced due to its significant

risks to human health and the environment. It is important to note that that cyanide and mercury should not be used in any way together, because that can greatly exacerbate pollution and health risks.

What can governments and health care workers do?

- Support (education, training, health care) should be provided to miners, their families and communities on the dangers of mercury and options for alternatives.
- Gain an understanding of the situation in your country/region and implement an environmental management strategy to monitor, regulate, etc.
- Subsidize equipment designed to reduce mercury release. This may additionally produce benefits such as reduced health care burden and costs as well as reduced environmental impacts.
- Encourage and assist communities to organize themselves to produce and market higher valued 'clean gold' to the market (see Association for Responsible Mining Case Study).

What are the barriers to the adoption of safer practices?

ASM is an important source of income in many rural communities and regions where economic alternatives are limited, particularly when gold prices are high. In addition, when there is a ready mercury supply and mercury prices remain low, market forces tend to work against the development of alternatives to mercury use.

Convincing miners to use less mercury because of health or environmental considerations is difficult. Programmes directed at reducing health risks from mercury need to be placed in the broader context of the overall living conditions of subsistence miners, their families and communities. Successful efforts to introduce alternative technologies are often those that demonstrate their economic benefits to miners.

Individuals will not be easily convinced of new practices introduced by outsiders. It is much better if the message is delivered by community leaders who are convinced of the benefits. For instance, such leaders can act as trainers and demonstrate sluice boxes that capture more of the fine gold particles (as in the Suriname case study), retorts that allow mercury to be recycled, or the promotion of higher valued "clean" gold to the fair trade market segment.

Where does the mercury come from?

In most countries mercury is imported legally for use in dental amalgams or the chlor-alkali industry. However, evidence from various developing countries and countries with economies in transition indicates that most imported mercury ends up being used in ASM. The unregulated trading of mercury from industrialized countries to developing countries and countries with economies in transition makes mercury easily available at the mine sites. In some cases mercury is provided free of charge, provided that the gold is sold to the mercury provider. Stockpiling of mercury by gold dealers is an additional health and environment concern/risk.

What efforts are being made on a global scale?

The Global Mercury Project

The Global Mercury Project (GMP) is a joint initiative with governments to demonstrate ways of overcoming barriers to the adoption of best practices in ASM, including waste minimization strategies and pollution prevention measures that limit contamination of international waters.

Pilot project activities focused on six countries -- Brazil, Laos, Indonesia, Sudan, Tanzania and Zimbabwe. At sites in these countries the GMP has been focusing on capacity-building programmes to remove barriers to the adoption of cleaner technologies. These programmes involve mobile training units that can reach miners in rural areas to create local priorities. This community assistance model is receiving widespread support, and the GMP has already certified teams of local trainers. Yet, the regions benefiting from the GMP constitute only a fraction of the global population impacted by ASM. Further commitment and resources are

needed in these and other regions and are being pursued in a second phase of the GMP (see: www.globalmercuryproject.org).

The Association for Responsible Mining and Green Gold (BRENDA CROSS CHECK)

"Fair Trade Artisanal Gold" is a label given to gold produced by artisanal and small-scale miners who respect a pre-defined set of social, economic, labor and environmental development standards in certain countries and regions that are participating in the programme. This is a process intended to help miners' organizations to minimize the use of mercury and cyanide over an agreed period of time, through implementation of responsible practices and technologies to mitigate impact on the environment and human health.

The Association for Responsible Mining (ARM) has proposed standards that include two "levels" of certification. The first level forbids the use of whole ore amalgamation, and requires the use of retorts and proper storage and handling of hazardous materials. The second "premium" level forbids the use of mercury or cyanide in production. When the ASM operator achieves this second level, their certified "Green Gold" is sold on local and international fair trade and green markets, and miners receive a bonus above the market value of gold that recognizes the benefits of a sustainable activity. More information on the program may be found in the Case Study.

Communities and Small Scale Mining

Communities and Small-Scale Mining (CASM) provides a coordinated network of shared information, a set of complete resources for use at the local level and a clearinghouse to distribute information to regional clean production centres.

CASM is developing good practice toolkits and guidance notes to improve the design and implementation of policies and programmes. It also supports and organizes workshops and conferences on artisanal and small-scale mining to bring together stakeholders to develop and transfer strategies for dealing constructively with the social, environmental and technical challenges posed by ASM and for maximizing the potential of these strategies where they are being practiced.

CASM awards small grants to community leaders, organizers, miners' groups, NGOs, and others whose proposed projects will foster communication, information sharing, and good working relationships between miners and communities (whether their own or other communities impacted by their activities); between small miners and big miners; and among various stakeholders involved in one way or another in the production process, such as mineworkers, small mine owners, mill mine owners, minerals traders, minerals transporters, creditors, land owners and governments.

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UNIDO to provide an additional study or two.

CASE STUDY: 'GREEN GOLD' AND THE ASSOCIATION FOR RESPONSIBLE MINING

Certified 'Green Gold', also known as Fair Trade Artisanal Gold, is produced through a sustainable, socially and environmentally responsible, small-scale mining programme that is based on fair trade practices and the observance of 10 mining certification criteria. 'Green Gold' is a registered trademark and is produced by artisanal and small-scale miners in participating countries and regions who agree to respect a pre-defined set of social, economic, labor and environmental development standards. The program was developed by the Association for Responsible Mining (ARM), which began its activities in Colombia, and is now working to develop Fair Trade Standards for minerals and gemstones worldwide.

The 'Green Gold' program is intended to support miners' organizations that are minimizing their use of mercury and cyanide over an agreed period of time through implementation of responsible practices and technologies to mitigate impact on the environment and human health.

The Certified 'Green Gold' criteria were developed using the traditional knowledge of the Afro and Indigenous communities of the Choco, the experience of local miners in their daily work, scientific knowledge contributed by the Institute of Environmental Research of the Pacific (IIAP) personnel, academic and technical orientation from mining experts, and the scientific knowledge and advice of Dr. Ranil Senanayake, who has undertaken "analog forestry" programs in Sri Lanka. The certifying body, IIAP, monitors bio-indicators to verify the rehabilitation of areas where the Green Gold program is implemented.

The proposed ARM standards for gold include two "levels" of certification. The first level forbids the use of whole ore amalgamation, and requires the use of retorts and proper storage and handling of hazardous materials. The second "premium" level forbids the use of mercury or cyanide in production. When the ASM operator achieves this second level, certified "Green Gold" is sold on local and international fair trade and green markets, and miners receive a bonus above the market value of gold that recognizes the benefits of a sustainable activity. The agreed-upon certification criteria are actually compatible with the community's ancestral mining techniques, in which chemicals such as cyanide or mercury were not used.

Land reclamation through the application of "analog forestry" techniques plays a central role in the scheme. Analog Forestry is an innovative technique that enhances the recovery of ecosystems and their biodiversity with a methodology that accelerates the processes of forest succession. The project is focused on replanting with food species. This produces cash crops that provide a source of income based on the marketing of rare and highly appreciated forest products, namely fruit, aromatic and medicinal plants, wood and fibers, among others.

The 'Green Gold' program has enjoyed a wide acceptance by beneficiary communities and by traditional miners in its pilot region. This is partially due to its bottom-up approach, which is consistent with the local Choco culture in Colombia, and to community participation in decision-making through Community Councils. The programme also strengthens community organizations, empowers communities and improves their capabilities, and increases food security and livelihood in mining communities. Certified 'Green Gold' is now sold in Colombia, the United States, the Netherlands, the United Kingdom and Germany, thereby creating a new market sector whose existence will encourage other sustainable mining projects.

For more information on the Green Gold Program and for links to participating and associated organizations, see the ARM website at http://www.communitymining.org/pilotoeng.htm

ARM invites membership requests to be made through a formal letter directed to the ARM Board of Directors, in which the interested party explains the work undertaken by the organization and the reasons why they want to form part of ARM. All requests must be sent to: arm@communitymining.org

Useful Links:

United Nations Industrial Development Organization (UNIDO) - Global Mercury Project:
www.unites.uqam.ca/gmf/intranet/gmp/index_gmp.htm

In the Documents section, find many valuable documents, including:
'Manual for Training Artisanal and Small-Scale Gold Miners,' Authors: Veiga MM, Metcalf SM, Baker RF, Klein B, Davis G, Bamber A, Siegel S, Singo P. *(2006)*

Communities and Small-Scale Mining website:
www.casmsite.org/

Standard Zero for Artisanal Gold:
www.infomine.com/publications/docs/AssocResponsibleMining2007.pdf

References:

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GMP, 2006. Global Impacts of Mercury Supply and Demand in Small-Scale Gold Mining. GMP Report to the UNEP Governing Council Meeting, February, 2007. Dated October, 2006.

International Labour Organization (ILO) (1999) *Social and Labour Issues in Small-scale Mines*. Report for discussion at the Tripartite Meeting on Social and Labour Issues in Small-scale Mines, ILO, Geneva

Veiga, M. M, P. Maxson, and L.D. Hylander (2006). Origin of mercury in artisanal and small-scale gold mining. *J. of Cleaner Production. 14*: 436-447.

Veiga, M.M. and Baker, R. (2004). Protocols for Environmental and Health Assessment of Mercury Released by Artisanal and Small-scale Gold Miners. Published by GEF/UNDP/UNIDO Global Mercury Project. Vienna.

Veiga MM, Metcalf SM, Baker RF, Klein B, Davis G, Bamber A, Siegel S, Singo P. *(2006).* 'Manual for Training Artisanal and Small-Scale Gold Miners'.

Acknowledgements:

Mercury Policy Project
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Marcello Veiga, University of British Columbia

Proposed Back Cover Page of each Module

Governments have agreed that there is sufficient evidence of significant adverse impacts from mercury and mercury compounds to warrant action on mercury. This publication was developed to raise awareness in certain countries and regions amongst stakeholders on the effects of mercury on human health and the environment. It is hoped that it will assist citizens, governments and health care workers to build support and the capacity to take action to reduce or eliminate mercury uses, release, and exposure to mercury.

This is one of six modules.

To find additional information on mercury and UNEP's mercury programme go to:
www.chem.unep.ch/mercury/

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Cover Page: Module 5

Mercury Use in Health Care Settings and Dentistry

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Key Messages

- Mercury is used in a variety of ways specific to the healthcare sector:
  - Mercury is contained in many common measuring devices, such as sphygmomanometers (which measure blood pressure), laboratory and patient-care thermometers and gastro-intestinal devices.
  - Mercury is found in some types of traditional medicines.
  - Mercury continues to be used for dental fillings worldwide.
  - Mercury compounds are found in certain preservatives, fixatives and reagents used in hospital laboratories and as preservatives in multi-dose vaccines in which bacterial growth needs to be suppressed.
- There are safe and cost-effective non-mercury alternatives for all uses of mercury in health care.

WHY IS THIS IMPORTANT TO YOU?

- Mercury spills associated with uses in health care contribute to the risk of human exposure in healthcare facilities.
- Improper disposal of mercury contaminates the environment locally, downstream and globally.
- There is limited awareness of mercury in medicines. Continued, repeated use of these products is a human health risk.

WHAT CAN YOU DO?

For the Public	For Health Care Workers	For Governments
• Use alternatives to thermometers containing mercury, where available. • Check labels on skin lightening products and Asian medicines for mercury and its compounds. Do not use products containing mercury or whose contents are unknown. • Choose mercury-free dental fillings where available.	• Know where mercury is used in your facility. Provide sound advice to potentially exposed people. • Work with administration to promote training, to implement policies for reducing mercury use and to procure mercury-free products. • Follow practical steps in your work environment to manage mercury carefully and to dispose of it properly.	• Encourage national assessments of mercury use and disposal. • Ensure that controlled mercury disposal and/or storage facilities are available and maintained. • Encourage the reduction of mercury use through voluntary initiatives or through regulation. • Regulate the manufacture, import and sale of unlabelled and mercury-containing healthcare products. • Make mercury-free medical devices available at government facilities. • Promote training in the health sector.

Mercury Use in Hospitals and Health Care Clinics

Where is mercury used in health care settings?

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Mercury is used in many different ways in hospitals, clinics and doctors' offices. First, mercury is contained in many common medical measuring devices: sphygmomanometers (blood pressure devices), thermometers (specifically body temperature thermometers but also others) and a number of gastro-intestinal devices, such as cantor tubes, esophageal dilators (bougie tubes), feeding tubes, and Miller Abbott tubes. As in other types of instruments, mercury has traditionally been used in these because of its unique physical properties, including the ability to provide highly precise measurements.

Mercury is also used in a number of products in health care settings not specific to healthcare, described in Module 2. These include electrical and electronic devices, switches (including thermostats) and relays, measuring and control equipment, energy-efficient fluorescent light bulbs, batteries and dental amalgam, and laboratory chemicals.

What are the risks in a hospital setting?
People are exposed to elemental mercury when medical devices containing mercury break and when liquid mercury spills or evaporates while bougie tubes and are other devices are being filled. Some devices, such as sphygmomanometers, contain quite a bit of mercury.

Mercury spills in hospitals, clinics and labs pose risks to doctors, nurses, other health care workers and patients. The most common exposure routes are through inhalation or through contact with the skin. The risk of exposure to mercury is highest in warm or poorly ventilated rooms.

Use of mercury products and devices in a hospital setting can also affect the downstream environment. Medical waste containing mercury, including the remains of a cleaned-up spill, can end up in aquatic environments and the atmosphere through improper disposal (see Module 3 on Mercury Discards and Wastes).

What alternatives are available for mercury-containing medical devices?
There are safe and cost-effective non-mercury alternatives for all uses of mercury in health care. Some developed countries have phased out mercury, including for mercury dental amalgam, as a health precaution. This has also helped to reduce mercury pollution.

It is important to purchase devices that have been independently tested and that meet required validation standards.

A key resource for mercury-free alternatives is the Sustainable Hospitals Project - a clearing-house of information on alternatives to certain toxic products in the health care sector, including mercury, PVC and latex: http://www.sustainablehospitals.org/cgi-bin/DB_Index.cgi

For alternatives to general products, please see Module 2.

What can governments do?
- Encourage national assessments of mercury use and disposal.
- Ensure that controlled mercury disposal and/or storage facilities are available and maintained.
- Encourage the reduction of mercury use through voluntary initiatives or through regulation.
- Regulate the manufacture, import and sale of unlabelled and mercury-containing healthcare products.
- Make mercury-free medical devices available at government facilities.
- Promote training in the health sector.

What can hospitals do?
- Know where mercury is used in your facility.

- Work with administration to implement policies for reducing mercury use and to procure mercury-free products.
- As for all hazardous substances, mercury spills should be handled according to agreed procedures. Such procedures should be developed for your workplace if they do not already exist.

- A mercury reduction initiative requires dedicated individuals, including members of both the healthcare institution and its external partners.
- The involvement of senior-decision makers is important because they can provide management and financial support for implementation.
- Any effective initiative for replacing mercury is dependent on the availability of alternatives, infrastructure for collecting and disposing of the leftover mercury, and financial resources available to the facility.
- A first step for a mercury reduction team might include raising awareness about the risks involved from mercury and the available alternatives. In-house medical professionals and environmental services personnel may be of assistance, as may NGO, university, and government resources.
- No single list of strategic priorities is universally appropriate. Every institution must develop its own strategy (see India and Argentina Case Studies). Some mercury reduction teams have had early successes by carefully prioritizing where to begin their initiatives:
    - For instance, sphygmomanometers contain more mercury than any other instrument and frequently break and spill, incurring substantial clean-up costs. Hence, replacing these devices might be a priority.
    - In others cases replacing mercury thermometers may be a more appropriate first step.

How should a mercury spill in the healthcare facility be managed?

- On-site spill management kits should be assembled and available for use in areas susceptible to spills.
- Instructions in managing spills should be clear to all staff through regular staff training and be made available in the spill kit. The following set of bullet points provides an example:
    - In the event of a mercury spill, remove all people from the contaminated area. Keep the heat below 20°C and ventilate the area if possible.
    - Wear nitrile gloves in the clean-up.
    - Use cardboard or folded paper to make a small scoop to gather the mercury "beads." Never use a broom or a vacuum cleaner.
    - Place all materials that have become contaminated in a sealable plastic bag and seal the bag. Place this sealed plastic bag inside an impact-resistant sealable container made of plastic or metal.
    - Put the container holding the contaminated material in sturdy secondary containers.
    - Keep all mercury containers tightly closed when not in use.
    - Store liquid mercury and mercury-containing waste in a cool place.
    - Post clearly visible signs in the storage area. Access to the storage area should be limited and contents should be monitored.

    See Module 3 for detailed procedures for managing mercury spills and mercury waste.

How does an institution properly dispose of mercury?

Wherever possible, always dispose of mercury as a separate hazardous waste.

The best current management practices for disposing of mercury involve using protected temporary storage in off-site hazardous waste warehouses. If no such storage facilities exist locally or within a distance that is safe and economically feasible, a local facility can store the mercury waste on-site. Ideally, however, mercury should only be stored there for a short period of time until it can be transported to a mercury recycling facility or a safe large-scale storage facility.

Never put spilled mercury in a sharps container for needles, syringes and lancets) – these are usually incinerated, which would spread mercury through the air.

Never put mercury down the sink or in a regular garbage can.

Mercury disposed of in regular garbage can be found by children - it is an extremely attractive plaything and there have been numerous cases of homes and schools contaminated by children playing with metallic mercury.

Mercury discarded in wastewater, burned with infectious waste or disposed of in landfills will eventually makes its way to aquatic systems where it is readily transformed by microorganisms into organic mercury compounds that ultimately enter the food chain.

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Mercury in certain medecines

What medicines contain mercury?

- Mercury-containing compounds are found in certain Asian medicines, such as traditional Chinese patent medicine and Indian Ayurvedic preparations. Regular users of medicines containing mercury are at particular risk.
- Mercury in the form of **'cinnabaris' (mercury sulfide), calomel (mercury chloride) or 'hydrargyri oxydum rubrum' (mercury oxide)** is included in some traditional Chinese herbal preparations (Ernst and Coon 2001; Ernst, 2002).
- A list of Traditional Chinese Patent medicines in the 'Pharmacopoeia of the People's Republic of China' (English Edition, 1997) lists 43 different products containing one or more of these ingredients; these products are used for a wide variety of indications, including ulcers, insomnia, and epilepsy.
- Some textbooks note the toxicity of mercury-containing products but include recommendations for preparation processes that reportedly 'detoxify' them, such as heating them until they glow, or cooking them with other ingredients (Prpic-Majic et al., 1996; Ernst, 2002).. Mercury is an element and cannot be further broken down. Detoxification processes are not relevant.
- Sold as non-prescription medicines, herbal products, and dietary supplements, these compounds are rarely subjected to the same rigorous testing, quality control, labeling, import or distribution regulations as are other medicines.
- Traditional Chinese medicines and Ayurvedic preparations are widely advocated in Eastern countries and have become increasingly popular in the West where they are imported both legally and illegally and are often available in health food stores (Ernst, et al., 2001).

Thiomersal and vaccines

Thiomersal (also known as thimerosal, mercurothiolate and sodium 2-ethylmercuriothio-benzoate) is a mercury-containing compound used to prevent bacterial and fungal growth in some vaccines during storage, and especially during use of opened multi-dose vials. It has also been used during vaccine production both to inactivate certain organisms and toxins and to maintain a sterile production line. Thiomersal has been used since the 1930s in the manufacturing of some vaccines and other medical products (WHO, July 2006).

Many licensed vaccines do not contain thiomersal. Such vaccines include vaccines in single-dose presentation or vaccines for which thiomersal would interfere with vaccine efficacy such as live vaccines including measles, mumps and rubella (MMR), oral and inactivated polio, yellow fever, and BCG vaccine. These vaccines, however, when in multi-dose presentations, have to be discarded at the end of the immunization session. Other vaccines may contain trace amounts of thiomersal (<0.5 µg per dose), if the preservative has been used in the production process, but has not been added to the final product. A third group of vaccines have thiomersal added in varying concentrations (10 to 50 µg per dose) as a preservative to prevent contamination with microorganisms when formulated in multi-dose vials. Such vaccines include vaccines against diphtheria, tetanus and pertussis (DTP), diphtheria and tetanus toxoids (DT), tetanus toxoid (TT), hepatitis B, *Haemophilus influenzae* type b (Hib), and influenza (WHO, July 2006).

Any change in the formulation of a licensed vaccine, including changes to the thiomersal content, may have an impact on the quality, safety and efficacy of vaccines and further trials are likely to be required before the reformulated product can be licensed. Replacing thiomersal with a different inactivating agent and/or preservative during the production process and/or in the final product, will require a new licensing process with a series of preclinical and clinical trials to ensure the quality, safety and efficacy of the vaccine. For vaccines used in multi-dose formulations thiomersal offers better protection from contamination than other preservatives such as 2-phenoxy ethanol (WHO, July 2006).

Single-dose vials require significantly larger cold storage space as well as increased transport needs. This is currently not feasible for many countries. For some vaccines, it is more cost effective to use multi-dose vials (WHO, July 2006).

Upon review of the current epidemiologic evidence and phamacokinetic profile of thiomersal, the Global Advisory Committee on Vaccine Safety concluded that there is currently no evidence of mercury toxicity in infants, children, or adults exposed to thiomersal in vaccines. It also concluded that there is no reason to change current immunization practices with thiomersal-containing vaccines on the grounds of safety. The safety of thiomersal-containing vaccines is reviewed at regular intervals. The WHO immunization policy with respect to thiomersal-containing vaccines remains (WHO, July 2006).

What can governments do?

- Regulate the manufacture, import and sale of unlabelled and mercury-containing healthcare products.
- Require the labeling of all mercury-containing medicines and healthcare products imported or sold to the public. This way people would know their ingredients and be able to avoid mercury products, allergens and toxins.
- Educate people about the effects of potential toxins, like mercury, so that consumers can make informed choices.
- Promote the training of health care providers, including in the recognition and treatment of mercury poisoning.

Mercury Use in Dentistry

What about mercury in dental fillings?

- In 2005 approximately 240-300 tonnes of mercury were used as an ingredient in dental restorations by dentists worldwide.
- Dental amalgam contains approximately 50% elemental mercury, 30% silver and 20% other metals such as copper, tin and zinc.
- Some countries are taking a precautionary approach and reducing the use of mercury in dentistry.
- Alternatives to mercury dental amalgam exist, such as composites (most common), glass ionomers and copolymers (modified composites). These are all effective alternatives that are generally considered more attractive than traditional mercury amalgams.
- Most dental practitioners continue to charge less for mercury amalgams than for the alternatives.
- The speed with which mercury amalgams are being replaced varies widely, and mercury use is still significant in most countries. In many lower income countries, changing diets and better access to dental care may actually increase mercury use temporarily, especially where people cannot afford higher treatment costs.

What are the risks?

- Dental sector occupational exposure levels to mercury are generally considered rather high, especially where the mercury amalgam is still mixed by hand.
- Use of mercury in the dental sector can impact on the downstream environment –mercury-containing waste from dental clinics often ends up in aquatic environments and the atmosphere through improper disposal and cremation. The primary source of mercury in municipal wastewater effluents generally originates from dental practice.
- There is considerable controversy over the risk associated with mercury fillings to the individual.
- The removal of sound amalgam fillings in patients who have no indication of adverse health effects attributable to mercury exposure is not currently justified.

What can you do?

- Reduce your personal need for dental fillings, practice good dental hygiene.
- If you are having a tooth restored, consider asking your dentist to use alternatives to mercury, such as composites should they be available.

What can dental professionals do to minimize risk in the use of mercury?

- Promotion of good dental hygiene reduces the need for any fillings.
- Follow practical steps in your work environment to manage mercury carefully and dispose properly of it.
- Use mercury-free substitutes whenever possible.
    - Where mercury is used, convert to single use amalgam capsules to help minimize the chance of an accidental mercury spill and exposure in the dental clinic.
    - Where mercury is used, reuse as much amalgam as possible.
    - Wear nitrile gloves when handling mercury. Do not use latex gloves because mercury penetrates latex.
- When possible, do not use amalgam fillings with people who have impaired kidney function. It is also recommended that amalgam fillings not be placed in or removed from the teeth of pregnant women (Health Canada, 1996).
- Carefully manage and store surplus mercury and encourage governments to establish collection programmes.
- Do not dispose of mercury in the trash. Always dispose of mercury as separate hazardous waste:
    - Never put scrap mercury amalgam in a sharps container (waste container for needles and syringes) - these are usually incinerated, which would spread mercury through the air.
    - Never put mercury-containing waste down the sink or in a garbage can.
    - See Module 3 for detailed procedures for managing mercury spills and mercury waste.

- The best current management practices for disposing of mercury involve using protected temporary storage in off-site hazardous waste warehouses. If no such storage facilities exist locally or within a distance that is safe and economically feasible, a local facility can store the mercury waste on-site. Ideally, however, mercury should only be stored there for a short period of time until it can be transported to a mercury recycling facility or a long term storage facility.

What are the general procedures in removing an existing mercury amalgam?

- Try to remove the amalgam in chunks rather than dust so it will be caught in the chair-side trap.
- Avoid removing mercury amalgam chunks with high speed suction (the vacuum line).
- Use a finer mesh on your traps (100 versus 40) if your suction system can handle it. It requires more cleaning but allows less pollution to go through.
- Consider purchasing an amalgam separator, which is a device that can remove amalgam from dental wastewater.
- Audit your office with equipment that detects mercury vapor (and which can be rented) to know and manage occupational exposure levels to mercury.

What can governments do?

- Promotion of good dental hygiene reduces the need for any fillings.
- Encourage mercury use reduction and proper waste management procedures in the dental sector, through voluntary or regulatory measures. Measures could range from implementation of proper waste management procedures to installing amalgam separators at dental clinics to reduce most of the emissions from wastewater.
- Establish collection programs to store safely surplus mercury from dental clinics.
- Ensure that controlled mercury disposal and/or storage facilities are available and maintained for hospitals and health care facilities.
- Governments should note that an additional source of mercury releases to the environment from mercury amalgam tooth fillings are crematoria. In addition, much of the mercury in municipal wastewater (originating from various sources but is often dominated by dental amalgam wastes) ends up in sewage sludge. Knowledge of the mercury content in sewage sludge is important.

> **Philippines Example:** The dental profession is slowly replacing mercury amalgam with composite materials, says Dr. Michelle Sunico, who is in charge of clinical operative dentistry at the College of Dentistry of the University of the Philippines. Dr Sunico counsels her fellow dental health practitioners about using amalgam substitutes whenever feasible and minimizing amalgam waste generation. “As dentists, we should also work towards caries reduction and prevention…thereby eliminating the need for amalgam," she says. Indonesia and Malaysia are also witnessing an increase in the use of amalgam substitutes in restorative dentistry, particularly in private practice.

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CASE STUDIES: Mercury Reduction Programs in Hospital Settings

CASE STUDY: HOSPITALS IN INDIA

St. Stephen's Hospital is a 600-bed (70% occupancy rate) multi-specialty hospital with a staff of 1650 people. For 120 years, it has been a centre of excellence, providing health care and health care teaching to thousands of people from all sections of the society. The hospital's planning for its mercury phase-out planning began in 2003, when in a training session conducted on occupational safety informed employees learned about mercury's toxicity. The hospital's concern for the safety of the staff, coupled with the fact that the hospital had acquired an ISO certification (International Standards for environmental management), made it imperative for the hospital to phase-out mercury.

The hospital took the following actions to ensure a smooth mercury phase-out programme:

- A written policy on mercury was drafted and included in the overall hospital policy document.
- The infection control committee was placed in charge of the programme.
- Written memoranda were sent to staff to inform them about efforts to pursue mercury reduction efforts.
- The hospital phased out mercury thermometers first and then mercury sphygmomanometers. The latter are being replaced with aneroid blood pressure instruments.
- The Purchasing Department is making no new purchases of any equipment.containing mercury.
- Regular training is being conducted for staff on how to prevent and manage mercury spills. Over 1000 nurses have been trained so far.
- A specific staff member has been designated to store all the mercury collected after each spill from the remaining mercury containing equipment. Approximately 2,130 g of mercury from spills were collected by the staff and sold to a thermometer manufacturer.
- Another staff member was assigned to calibrate mercury sphygmomanometers. This ensures that this person understands the safety measures that need to be taken while handling mercury.

The number of mercury thermometers issued per year has gone down from 687 in 2002 to zero in 2005. Even though certain mercury-containing equipment can still be found in some wards, the hospital remains committed to phasing it out completely over time. St. Stephens plans to address the issue of mercury-containing dental amalgam in the future by using alternatives and collecting it for safe disposal. (clarify location)

Sir Ganga Ram Hospital is a 650-bed (100% occupancy rate) state-of-the-art hospital in Delhi with multiple specialties and 2,148 staff members. For 48 years, it has provided comprehensive health care services to the community. The potential environmental and health risks associated with mercury convinced the hospital to adopt a mercury phase-out program in 2004. It started by drafting a mercury reduction policy and assigning a senior administrator to oversee the two-phase programme. The plan included the following steps:

- Written memoranda informed staff about mercury and mercury-reduction efforts.
- Laboratory and dental departments were involved in finding ways to eliminate their use of mercury.
- Waste mercury was collected in sealed containers that were handed over to a disposal squad.
- The staff was trained on how to prevent and manage mercury spills.

Mercury thermometers were successfully phased out first, and in the dental wing 80% of the restorations are now mercury-free. During the current second phase the hospital is replacing its mercury sphygmomanometers with aneroid units.

Max Devki Devi Hospital is a newly constructed, 178-bed hospital. When the facility was in the planning phase it was decided that only digital thermometers and sphygmomanometers would be purchased. Since the decision to obtain mercury-free equipment was made during the planning stage itself it was easier to implement later. Although the hospital has not had a formal policy for preventing mercury greatly eased the problem. In 2004 the hospital conducted training sessions on occupational safety, including the hazards of mercury, at its other locations throughout the city. (clarify location) The phase-out of mercury at those facilities has become part of the hospital's long-term strategy.

The Holy Family Hospital is a 300-bed multi-specialty hospital with 1,200 staff. It offers three schools of treatment: allopathic, homeopathic and ayurvedic. The hospital's mercury-reduction efforts began in December 2005. The hospital adopted a mercury phase-out program that included a purchasing policy banning the purchase of new mercury thermometers and sphygmomanometers. It replaced all the mercury thermometers in the neonatal ward with digital ones. A system for collecting spilled mercury was put in place, and a staff member identified for its collection and storage. Approximately 500 g of mercury, collected from spills, have been sent for recycling. The staff now receives regular training on preventing and managing mercury spills. Over 160 nursing staff have been trained so far. (clarify location)

Lessons learned in India:

1. Success depends upon committed staff in the health care setting.
2. A written policy on mercury hazards and alternatives is a useful tool for communication.
3. Good communication between the administration and the staff is vital.
4. The phase-out requires endorsement and commitment at all levels of the organization.
5. Healthcare workers may resist moving away from the familiar mercury-containing instruments. They may question the accuracy and/or the cost of the alternatives. However, when hospitals train the staff on the use of alternatives, the change-over will be gradually accepted.
6. New facilities should plan from the outset to purchase mercury-free equipment.

CASE STUDY: ARGENTINA
RIVADARIA HOSPITAL

Several excellent examples of mercury-reduction initiatives in the healthcare sector are found in Argentina. At the Rivadaria Hospital in Buenos Aires a small survey was initially distributed to medical staff in the Neonatal Intensive Care Unit (NICU). As a result of the interest generated by the survey, a series of educational seminars on the life cycle and human health impacts of mercury were presented to hospital staff.

The hospital director authorized the purchase of digital thermometers for a small pilot project. Each NICU nurse was given a digital thermometer and trained how to use it properly. News of this project spread quickly to other facilities within the city. Thereafter, the Pediatric Hospital at Hospital Elitazlalde received a donation of digital thermometers. As awareness of the health impacts of mercury and these programmes grew, the city government signed a Letter of Intent to phase-out mercury thermometers. Within about a year, 33 neonatal units across the city had eliminated or were in the process of eliminating their use of mercury thermometers.

Interest and involvement in mercury education quickly grew. This provided the impetus for a Latin American Conference on Mercury-Free Healthcare that have helped generate additional interest and understanding throughout Argentina and other parts of Latin America.

The conference led to resource-sharing and further education on health impacts, reduction strategies and spill management. Three months after the event a number of hospitals had developed low-cost spill clean-up kits and were educating staff on proper spill management. Posters and other educational resources are now available in many hospitals.

Facilities outside of Buenos Aries have also begun now to reduce the use of mercury. For example, a facility in the City of Esquel, in the Province of Patagonia, has eliminated all mercury thermometers and replaced them with digital alternatives. As a result of education and training, the collected mercury devices are now stored on-site at these facilities, in sealed containers, as plans towards a local waste mercury management system evolve.

Rivadaria Hospital is now in the process of replacing mercury blood pressure devices containing mercury with mercury-free aneroid alternatives. The experience of Argentina illustrates the momentum that can be generated by a step-wise approach to eliminating mercury and demonstrates how education and resource-sharing can remove the major obstacle presented by a lack of knowledge and awareness. While much remains to be accomplished, there is now a widely-shared recognition in Argentina that mercury is an important and significant public health concern.

CASE STUDY: NORWAY
TORDIS KLAUSEN, DENTAL ASSISTANT

For 12 years, Tordis Stigen Klausen, a former dental nurse in Norway, struggled to convince health authorities that she had become ill due to occupational exposure to mercury. In January 2006 she was awarded the prestigious *Zola* prize for her work in spreading information about the damage to health from exposure to dental amalgam and mercury in dental clinics. The *Zola* prize is awarded in Norway to persons who, "Openly and courageously have revealed or opposed conditions in Norway that threaten basic values in Norwegian society: human rights, democracy and legal protection."

Ms. Klausen had worked as a dental assistant in a municipal dental clinic in Norway for 23 years during the 1970-80s. During this period nurses prepared amalgam by hand. They heated amalgam, containing 69% mercury, in a spoon until the mercury appeared in droplets on the surface, and then kneaded the amalgam in their bare hands. Starting in 1978, Ms. Klausen began to experience symptoms consistent with mercury intoxication.

In 2005 Norwegian Television Broadcasting aired a documentary on her struggle. Two documentaries were produced known as Burning Point (*Brennpunkt)*: the first was about occupational exposure and health damage to dental assistants from mercury called *Kvikksølvjentene* (The Mercury Girls) and the second was about health damage and birth defects to children of dental assistants called *Kvikksølvbarna* (The Mercury Children).

Phone lines were set up to receive calls from viewers after the broadcast. Within two months 394 women had called. It became clear that many dental nurses had worked while pregnant and breastfeeding. A high number reported that their children had been born with birth defects, had severe depressions, learning difficulties, immunological and muscular/skeletal problems. In addition, the mothers had severe bleedings and multiple late abortions. These results were similar to those found in New Zealand where nurses were exposed to similar levels of mercury.

In response to the documentaries, Norwegian and Danish government studies are now underway.

FOR ADDITIONAL INFORMATION

Kjersti Knudsson is the director of the documentaries; *Mercury Girls* and *Mercury Children*. Information about the Norwegian Broadcasting documentaries can be found at:
Mercury Girls: http://www.tv2world.com/programmes/show/109
Mercury Children: http://www.tv2world.com/programmes/show/110

Anyone interested in airing the documentaries should contact TV2 WORLD DENMARK, www.tv2world.com The e-mail addresses for the sales office is sales@tv2.dk and their telephone number is +45 65 21 22 23.

Also, see the link to a BBC article about this research which is still on internet:
http://news.bbc.co.uk/hi/english/health/newsid_1957000/1957380.stm

Useful Links:
Healthcare Environmental Resource Center: www.hercenter.org

Health Care Without Harm website: www.noharm.org/us/mercury/issue

"Mercury in Health Care Fact Sheet, June 2006."
Available on the European Public Health Alliance website: www.epha.org/a/2455

A key resource for mercury-free alternatives is the Sustainable Hospitals Project - a clearing-house of information on alternatives to certain toxic products in the health care sector, including mercury, PVC and latex: www.sustainablehospitals.org/cgi-bin/DB_Index.cgi

National Institutes of Health: www.nih.gov/od/ors/ds/nomercury/alternatives.htm

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Acknowledgements:
- Mercury Policy Project
- World Health Organization

Proposed Back Cover Page of each Module

Governments have agreed that there is sufficient evidence of significant adverse impacts from mercury and mercury compounds to warrant action on mercury. This publication was developed to raise awareness in certain countries and regions amongst stakeholders on the effects of mercury on human health and the environment. It is hoped that it will assist citizens, governments and health care workers to build support and the capacity to take action to reduce or eliminate mercury uses, release, and exposure to mercury.

This is one of six modules.

To find additional information on mercury and UNEP's mercury programme go to:
www.chem.unep.ch/mercury/

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Cover Page: Module 6

Cultural Uses of Mercury

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Key Messages

- Mercury has been used for hundreds of years for cultural and religious reasons and has, on occasion, had mythological associations.

- A number of practices exist today that use mercury, including: Santería (an Afro-Hispanic belief system), Palo Mayombé (Caribbean), Candomblé (Afro-Brazilian), Voodoo (Afro-Haitian), Espiritismo (Puerto Rican) and Yoruba Orisha (Afro-Hispanic). Mercury is also used in Hindu practice as a major constituent of Parad, from which religious relics are made.

- In some cases, mercury is injected subcutaneously, intravenously, or intramuscularly to improve athletic prowess or protect users from evil.

- Exposures resulting from cultural uses depend to a large extent on the nature of the practice: swallowing elemental mercury capsules and inhalation of mercury vapor are the most common exposure routes.

WHY IS THIS IMPORTANT TO YOU?

- Direct and prolonged exposure to mercury is a human health hazard and has an impact on the downstream environment.
- People using mercury for cultural uses are often unaware of mercury's toxicity and associated risks.
- The storage, transport and handling of mercury for these purposes can impose risk by introducing opportunities for spills and vapor releases.

WHAT CAN YOU DO?

For the Public	For Governments and health care workers
• Be aware that mercury is dangerous and the risks of mercury use! There is no safe way to use mercury and scientists have found no safe mercury level in the human body. • Help raise awareness about mercury exposure risks with your family and in your community. • Dispose of mercury-containing products separately, not with other trash.	• Identify communities or cultural groups that use mercury for cultural/religious purposes. • Embark on a public awareness campaign for mercury reduction with targeted cultural groups, engaging health professionals and cultural/spiritual leaders. • Develop and distribute informative material for the public on mercury and its toxic effects. • Ask the mass media (newspapers, magazines, radio and television) to help you educate the community on the dangers of the use of mercury. (As an ex-journalist I can assure you that the media hate to be "used".) • Encourage reduced mercury use through voluntary promotional initiatives or through regulation of production and sales. • Measure mercury concentrations in dwellings and commercial establishments in the affected area and use this information to communicate risks.

What is the history of mercury use for cultural purposes?

- Mercury has been used for hundreds of years for cultural and religious reasons and has, on occasion, had mythological associations.
- Mercury was brought to the New World by Spaniards for use in extracting gold from ores. Its amalgamating properties led to a belief that mercury attracts good fortune, wealth and love.
- Other characteristics of mercury have led to a range of beliefs. Some people believe its characteristic sudden movements mean it will furnish remedies more quickly. It is also said to prevent evil or bad luck from sticking to a person because it seems slippery.
- China's first emperor, Qin Shi Huang Di (260 BC – 210 BC) took mercury pills in an attempt to achieve eternal life, but instead he died from mercury poisoning.
- In the 13th through 17th centuries, mercury was used in India in elixirs believed to confer immortality.

What are common cultural practices that use mercury?

Mercury has long been used in ethnocultural or religious practices such as Santería (an Afro-Hispanic belief system), Palo Mayombé (Caribbean), Candomblé (Afro-Brazilian), Voodoo (Afro-Haitian), Espiritismo (a spirit-focused belief system native to Puerto Rico) and Yoruba Orisha (Afro-Hispanic).

Most of these uses are associated with African roots, and many of them are related the Roman Catholic teachings of Spaniards. The use of mercury - also known as azogue (Spanish) or vidajan (Creole) for such practices – has been documented in many countries, including by minority populations in large cities. Mercury is also used in revised Wiccan (witchcraft) practices. Mercury is employed in Hindu practices as a major constituent of Parad, from which religious relics are made.

How and why is the mercury used?

Sometimes mercury is used to facilitate or to hasten desired results, such as:

- Sprinkled on the floor to protect occupants of a car, home etc.. This is done in children's rooms, around the crib or bed, and in cars, to prevent accidents.
- Used with water and a mop for spiritual cleaning of a dwelling.
- Added to oil lamps and candles which are then burned to ward off evil spirits; bring good luck, love or money; or to hasten other spells.
- Used in various ways to cast love spells (Greenberg, 1999), heal or dispel evil influences.

Cultural and/or religious practices with mercury use include:

- Carried in amulets, ampoules, vials, or pouches worn around the neck or carried on the person.
- Used to make religious statues or other objects, such as parad shivling (see Case Study: Hindu Mercury Use in 'Parad').
- Applied to the skin or used in bathwater, perfumes, lotions or soaps.
- Injected subcutaneously (to ward off evil and protect against exposure to disease while traveling) (Prasad, 2004) or intramuscularly (to help athletes build muscle mass) (Celli and Khan, 1976).
- Ingested for superstitious or medicinal purposes (Greenberg, 1999), including steeped in raw milk before the milk is drunk.
- Mercury and mercury compounds are also used in culturally specific medicinal compounds, such as Asian medicines (see module 5 Health Care).

Some examples of risks associated with common practices:
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Mercury in candles: Mercury is sometimes used in candles where it typically sinks into the wax and is trapped, at least until the candle is completely burned. Some mercury is volatized when the mercury is initially poured into a candle – enough to cause significant exposures to mercury vapour indoors. If exposed directly to the flame at the base of the candle, the mercury will volatize even more quickly than it normally does (Riley *et al*, 2001).

Mercurycapsules: *Mercury capsules known as Azogue, sold in religious stores,* is sometimes used as a Mexican folk remedy for indigestion or gastroenteritis blockages (*empacho*). Ingestion of the heavy, mobile liquid mercury is believed by practitioners to dislodge gastrointestinal blockages, particularly in children (Geffner and Sandler, 1980). Mercury ingestion generally leads to both digestive and renal problems and neurological symptoms. Diagnosis is complicated by the similarity between the symptoms from consuming the mercury and the symptoms of the illness it is used to treat.

Mercury use in the home: Mercury is sometimes kept in containers, such as pots or cauldrons, in the home. These are sometimes sealed but other times left open to "purify" the air. In the Palo belief system a significant quantity of mercury is one of the most important of many special and mystical ingredients when brewing up the cauldron which is believed to have a spirit in it. Sometimes mercury is mixed with water, ammonia or camphor, or a magnet is placed in it. Other times it is kept in a gourd or piece of fruit. The most common use of elemental mercury in Latin American and Caribbean communities in New York City is in a container in the home. This practice is found in more than 30% of homes in Latin American communities and in about 25% of homes in Caribbean communities in New York City (Johnson, 1999).

What are the risks?

- Exposures resulting from cultural uses depend to a large extent on the nature of the practice:
  - The most common exposure pathway is through inhalation of mercury vapours. This is of particular concern especially in closed spaces. Approximately 75-85% of inhaled mercury vapour is absorbed and enters the bloodstream. Any mercury held in unsealed containers or spilled will result in mercury vapour.
  - In particular, the practice of sprinkling mercury in a car can result in very high vapour concentrations, especially after the closed vehicle has stood in the sun on a warm day. Similarly, vapour concentrations in contaminated dwellings can increase in colder weather, when the room or apartment is closed and possibly heated (Johnson, 1999).
  - Swallowing elemental mercury capsules is the leading cause of poisoning by metallic mercury, as well as a source of mercury vapor poisoning.

- Special risks are involved in the storage, transport and handling of mercury which introduce opportunities for spills and exposures, both immediate and longer-term.
- Unsuspecting persons can be poisoned by exposure to mercury spilled by previous residents of their dwelling. Mercury can linger in cracks in the floor, carpeting, dirt and even concrete for many years, slowly volatilizing.

What can you do?

- Be aware of the risks of mercury use and share this knowledge with your family and friends!
- Always dispose of mercury and mercury containing products as separate hazardous waste (see Module 2).
- Non-governmental organizations can initiate a public awareness campaign with cultural groups in your area who are known to use mercury.

What can healthcare professionals do?

- Be aware of the symptoms of mercury poisoning and how patients might be exposed to mercury.
- Help bring together community groups and leaders and government (e.g., Health Department) personnel to discuss ways to publicize the risks associated with mercury.
- Design and distribute informational posters on mercury exposure, risks and symptoms in the local language for public gathering places and see that these are placed in clinics, doctors' offices and hospitals.

What can governments do?

- Develop printed informative material, such as leaflets or posters, on mercury exposure and toxicity in local languages. Distribute or post these in targeted public places, transportation centers, government buildings, hospitals, schools and particularly stores that sell mercury.
- Work closely with the mass media (print press, radio and television) to educate the community on the dangers of the use of mercury.
- Meet with members of cultural groups using mercury, engaging health professionals, cultural/spiritual leaders and local distributors (e.g., botánicas owners and sanadores) in the discussion. These meetings can serve as a forum to understand the use of mercury and share ideas. They could also be useful forums to explore alternatives to mercury use.
- Educate the small distributors and the community at large.

- Encourage mercury use reduction by promoting voluntary initiatives or regulating import or sales of mercury and mercury containing products.
- Require that mercury be labeled as hazardous and that signs regarding exposure risks be posted at point-of-sale.
- Prohibition of the sale of mercury can be effective in reducing mercury use for cultural purposes and is most effective with inspection follow-ups. Prohibition can lead to a significant increase in cost of mercury capsules on the black market (see Case Study: Puerto Rico).
- Secure proper waste management facilities. See module 2.
- Measure contamination levels at locations where mercury is sold and/or used to measure and communicate risks.

What are the potential barriers in changing cultural practices?

For many ritual and cultural uses of mercury, safer substitutes are identified and readily available.

There is a general lack of awareness of the risks of mercury use as well as available alternatives amongst cultural leaders, communities and people who sell the products.

It is usually difficult at first for individuals to consider changing long-standing cultural or traditional practices. Furthermore, experience has shown that even if users recognize that mercury is considered toxic, they may believe that its ritualistic or supernatural nature renders it harmless or the user beyond harm. Strong messaging including concrete examples demonstrating the risks can have an impact.

Convincing cultural leaders of mercury risks is of uppermost importance. Trusted health care leaders can play a big role in relaying the message.

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Example: The use of mercury in Santeria

Santeria is an Afro-Hispanic belief system. The use of mercury for Santeria and other spiritual practices has been reported in the Dominican Republic, Cuba and other Caribbean islands, Suriname, Belize, Trinidad, Jamaica, Peru, Ecuador, Argentina, Brazil, Colombia, Mexico, Venezuela, Guyana, France, the Netherlands, and Puerto Rico (Wendroff, 1991). Santería was actively suppressed in Cuba after Fidel Castro's revolution – particularly during the 1960s. However, oppression has now largely ended, and the popularity and practice of Santería has increased in Cuba during the 1990s.

Typical Practices: Mercury is used in a variety of ways that pose a poisoning risk to users. Some uses identified in Santeria are:

- Place mercury in water or in a tea bag with some coins.
- Carry a capsule of mercury in an amulet on a chain or between two coins in a wallet.
- Throw a capsule of it in bath water.
- Swallow a capsule of mercury mixed with holy water.
- Burn mercury in a candle.
- Wash the house with water containing mercury to purify it.
- Put mercury under the bed.
- Swallow a capsule of mercury, sometimes mixed with water, for stomach ailments or cancer.
- Take mercury with beer to increase virility.
- Rub a mixture of mercury and alcohol on an area affected by arthritis.
- Put mercury in a glass near a candle so that it evaporates quickly.
- Mix mercury with other ingredients for use in sorcery.
- Apply mercury to the skin during massages.

In communities and regions where these practices are prevalent, mercury is typically sold in capsules from "botanicas" or "yerberias," which are small, privately owned shops that sell popular religious articles, as well as a variety of products believed to have medicinal or healing properties. Mercury is sometimes sold in gelatin capsules with a capacity of more than 13.5 g, but which typically contain 8-9 g mercury (Riley *et al*., 2001). A capsule can contain up to 10 times more mercury than one thermometer. Small glass jars or plastic bottles or even plastic bags are sometimes used as well, and these may contain as much as 65 grams of mercury.

Most customers arrive at botánicas with a prescription received from a sanador. Besides selling products, some botánicas offer spiritual inquiry services for clients. Usually these consultations are offered in a room inside the botánicas that has been designed for that purpose. Generally, the person that offers these consultations is a spiritualist medium or santero. Some botánica owners function as counselors for their clients and offer social and emotional support.

Case Study: **PUERTO RICO: PROHIBITION OF MERCURY SALES IN BOTÁNICAS**

In 1991 the Puerto Rico Department of Consumer Affairs (DACO) issued an order prohibiting the distribution and sale of mercury capsules.

The order followed a visit to a botánica by an inspector of the Department of Health. In the botánica, the inspector bought two capsules of silvery liquid. These capsules were analyzed by the Department of Health and it was confirmed that they contained mercury. The average price of a mercury gelatin capsule in botánicas at the time the research was done was $US 2.00, although some botánicas charged as much as $5.00. (The price of the mercury had increased significantly after the Department of Health prohibited its sale in botánicas. Prior to this regulation a capsule of mercury could be bought for $US0.75.)

DACO intervened at the level of the two mercury distributors in Puerto Rico. The presidents of both companies denied having sold capsules of mercury to owners of botánicas. They agreed to impose a fine of $10,000 on people who violated this prohibition.

Despite the fact that most botánicas owners are aware of the regulation, a significant percentage of botánicas continue to sell capsules of mercury. In a study that followed the prohibition 132 botánicas were identified in 74 towns:

- The majority of the botánicas were located in the coastal areas. 41% of 76 botánicas visited by researchers sold mercury. Researchers found that botánica owners were reluctant to speak about mercury because of a ban on sales, and most initially denied that they had any for sale.
- In 7 cases, owners of botánicas that did not carry mercury sent the customers to others who did sell it or recommended that they obtain it from thermometers.
- About 50% of botánicas owners knew that the sale of mercury was prohibited because it can damage health, and they adhered to the restrictions. These owners do not have mercury for sale and they tell customers who ask that the sale of mercury has been prohibited because it is dangerous for health.
- Some owners of botánicas know that the sale of mercury is prohibited, but continue selling it to their clients. Some of these owners advise customers on how to utilize mercury in a way that they say is not toxic. These people very likely continue selling mercury because they are not convinced that mercury is toxic or because they have a financial interest in selling mercury that outweighs its negative health effects. Other owners of botánicas sell mercury knowing its toxic potential but believing that if it is used in a certain way the mercury will not do damage – these owners tend to advise customers on the toxic potential of mercury.
- According to owners, candles are the most frequently sold product.

24 sanadores, Santeria spiritual leaders (sanadores), in the western part of Puerto Rico were interviewed to find out how they use mercury and whether they know of its risks. All but two admitted knowing of mercury use, six knew that it was dangerous to health, and four knew that its sale was prohibited.

Botánicas are an important source of information and support system for a significant part of the Puerto Rican population. They perform important therapeutic, economic, and social functions in the community. Their name evokes uses of medicines and natural substances, and their context implies traditions of healing and popular medicine. The botánicas have a great variety of products available.

While some botánica owners function like sanadores, others merely sell products for a profit whether they believe in their effectiveness or not. Some attribute the effectiveness of the products to the faith that the user places in them and confess that most of the products they sell are simply not necessarily effective.

SOURCE: This is based on a case study from a Spanish language document: Course notes Sistemas Folclóricos de Ayuda, Módulo 8: El mercurio: http://www.uprm.edu/socialsciences/sfaenlinea/id15.htm.

By Mario Núñez-Molina. Universidad de Puerto Rico, Recinto Universitario de Mayagüez

Example: Hindu mercury use in 'Parad'

Parad is an amalgamation of mercury and other metals that is used to make relics for worship of God in the Hindu tradition. Solidifying mercury is an ancient Vedic 'science.' 'Dharnidhar Samhita' (scripture) has prescribed sixteen steps through which elemental mercury has to pass to purify it and bring out its beneficial qualities before it is alloyed (mixed with other metals) to make parad, which can be molded into any solid form. Parad is traditionally made of silver and mercury, but it is now often made of mercury and tin, with trace amounts of other metals.

To people who practice this, the benefits of parad are said to be many and varied, and may include:

- Vaastu or Tanrik dosh nivaran (removes bad luck from the workplace or home)
- Curing a range of diseases
- Warding off evil spirits
- Establishing an inner spiritual balance
- Increasing willpower
- Stopping nightmares
- Resolving marriage problems

In Hindu culture, it is traditionally believed that the worship of parad shivling (an abstract image of God, an icon or statue) will destroy sins. It is said in Brahma Purana scripture that any person who worships parad idols devotedly will receive full worldly pleasures - glory, honor, high office, fame, sons, grandsons and learning - and upon death attain supreme destination (salvation). Various religious objects are made of parad and sold in markets in India. These include: beads worn around the waist or neck, amrit (a nectar or ambrosia) cup, Shivling (an abstract image or statue of God), Lakshmi (a representation of the Goddess of wealth), and a Ganesh (an idol of Lord Ganesh). India has many Shiva temples, which have parad shivlings. Sales of parad statues, jewelry and other artifacts through websites and television are widespread in India.

Case Study: Toxics Link studies mercury levels in Parad

The Indian non-governmental organization Toxics Link initiated a study of parad following the creation of a 500 kg parad shivling at Siddha Ashram. Their objective was to identify the extent of this traditional use of mercury and the cultural significance of parad, identify possible sources of parad in the region, determine the material composition of parad, and test the leaching behavior of parad in milk (this test was chosen because the shiv puja involves immersion and bathing of shivling by milk and drinking of that milk by the devotees). Studies revealed that the primary chemical composition of Parad by % weight is tin 74.8 %, mercury 24.9 %, and other metals at low percentages (including silver at 0.04%). Tests showed that mercury in parad does indeed leach in milk and water, potentially exposing anyone who drinks milk that has been used to soak parad relics or drinks from parad cups.

Toxics Link is trying to raise awareness and educate the public directly on the toxicity of mercury.

Acknowledgement: This case study was provided by Toxics Link, a non-governmental organization in India. Toxics Link emerged from a need to establish a mechanism for disseminating credible information about toxics in India, and raising the level of toxics debate. Currently it has a main office in New Delhi as well as offices in Mumbai and Chennai.

Useful Links:

"The Ritual Use of Mercury," an audio (broadcast) segment.
For more information see: http://homepage.mac.com/cynthiagraber/

Fact Sheet – 'The Use of Mercury for Cultural and Religious Purposes.'
National Association of County and City Health Officials.
http://archive.naccho.org/documents/MercuryFactsheet.pdf

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Mercury Policy Project

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www.chem.unep.ch/mercury/

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