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**Executive summary of the report on the extent of contaminated
sites**

The Executive Director has the honour to provide, in the annex to the present note, the executive summary of the report on the extent of contaminated sites for the consideration of the Governing Council. The annex has been reproduced without formal editing.

* UNEP/GCS.25/1.

Annex

Key findings of the report on the extent of contaminated sites

The UNEP Governing Council at its 24th session in February 2007 requested the Executive Director to prepare a report drawing on, among other things, ongoing work in other forums addressing an analysis of information on the extent of contaminated sites, the risks to public and environmental health of mercury compound releases from such sites, environmentally sound mitigation options and associated costs and the contribution of contaminated sites to global releases. The study has been prepared drawing upon relevant open literature publications, relevant UNEP reports, reports of meetings and projects and monographs prepared by various research groups.

This study confirms that it is difficult to develop robust data on the extent of contaminated sites and/or quantification of releases or pollution due to the limited data available. Total mercury emissions to the atmosphere and hydrosphere from contaminated sites are estimated to be between 150 to 300 metric tonnes per year. As the extent and distribution of mercury releases depend strongly on the climatic conditions and the topography of the site in question, extrapolations from a few well studied cases are associated with large uncertainties.

Releases from contaminated sites are estimated to contribute less than 5% of current total mercury emissions from anthropogenic sources annually. It should be noted, however, that these secondary mercury sources will continue to emit mercury for a very long time, if not managed properly and/or remediated. Poor management of contaminated sites may increase the level of releases resulting in an increased risk for local populations and ecosystems at large, with studies showing severe exposure especially in sensitive members of the population.. Remediation of such sites can be expensive, and decisions on when to treat are complex. Further studies are needed for the development and implementation of effective programmes to protect the populations residing in or near mercury contaminated sites. An integrated approach for the management of contaminated sites, including guidelines for characterisation and remediation of contaminated sites should be developed.

Executive summary of the report on the extent of contaminated sites

Introduction

The UNEP Governing Council at its 24th session in February 2007 requested the Executive Director to prepare a report drawing on, among other things, ongoing work in other forums addressing an analysis of information on the extent of contaminated sites, the risks to public and environmental health of mercury compound releases from such sites, environmentally sound mitigation options and associated costs and the contribution of contaminated sites to global releases.

This “Global study on contaminated sites” has been prepared to provide information about contaminated sites as requested in the decision.

This document has been prepared drawing on relevant open literature publications, UNEP reports prepared in cooperation with UN Agencies (UNIDO, UNDP, WHO, FAO), reports of meetings and projects and monographs prepared by various research groups.

Mercury (Hg) is a naturally occurring element found in all environmental media. It is distributed throughout the environment by both natural processes, such as volcanoes and leaching from soil as well as anthropogenic (human) processes. Mercury is found in various inorganic and organic forms and is persistent in the environment. The three predominant forms include: a) elemental mercury; b) ionic mercury (also known as inorganic mercury; and c) organic mercury with methyl mercury being the most important.

Mercury continues to be used in a variety of products and processes all over the world because of its unique properties. Elemental mercury is used in artisanal and small-scale mining of gold and silver; chlor-alkali production; vinyl chloride monomer production, and in products (such as manometers for pressure measurement and control, thermometers, electrical switches, fluorescent lamp bulbs, and dental amalgam fillings). Mercury compounds are used in some batteries, pharmaceuticals, paints, and as laboratory reagents and industrial catalysts. Production, uses and disposal the mercury-containing products and wastes can result in the release of mercury to the environment.

Mercury enters into the environment in many different forms. As the toxicological impacts of Hg are largely dependent on chemical form the mercury is in, understanding its transformations and the impacts of various chemical forms is vital to the prevention of harmful human and environmental health effects. Ultimately, the type of mercury present in a given environment depends on the form which was released, the thermodynamic stability of this compound and the transformation rate of the released form to a more stable one. These issues must be well understood to effectively design and evaluate appropriate remedial solutions in mercury impacted areas.

Source categories of contaminated sites

Depending on the mercury source and how it was released into the environment, mercury may be present in concentrated "hot spots" or dispersed over extensive areas. “Hot spots” are defined as sites containing high mercury concentrations relative to the local contamination in soils and sediments. Hot spots may result from a single well-delimited pollution source. The area concerned is small – a few hundred square meters – but the potential consequence in terms of human exposure is significant for the local population. Hot spots may also result from several associated single-source releases. The concerned area is much more extensive than in the previous case, and the associated pollution impact can be regional with a radius exceeding the tens of kilometer scale. The contamination is more diffuse and may affect the whole population living in the area.

Contaminated sites mainly arise from mercury uses such as mercury mining and smelting, Artisanal and Small-scale Gold Mining (ASGM), primary & secondary non-ferrous metal smelters, chlor-alkali plants and mercury containing products industry.

Industrial scale mining

Mine wastes deposited in the nearby environment and contaminated soils represent an important source of mercury to the atmosphere due to evaporation. Most importantly particulate mercury and soluble ionic mercury species that can be released into water, transported from the mineralized site and converted to methyl mercury in downstream aquatic environments. Release and transport of mercury from mine wastes occur primarily as mercury-enriched particles and colloids.

In temperate climates the release of mercury from mine wastes occurs primarily in the particulate form, and most of the mercury flux occurs during peak flow periods. In arid climates, however, the transport of mercury from mine sites is limited and watersheds are not usually impacted at distances greater than 1 km from the mine. Mercury mine wastes deposited adjacent to streams may be removed by flood events, thus providing renewed space for continuous mine waste disposal during the life of the mine. The release of mercury from mine wastes is dependent on particle size because mercury concentration increases with decreasing particle size such that the fine-grained fraction may have twice the mercury concentration of the coarsest fraction. Mercury particles dispersed in water are an important transport mechanism from mine wastes.

At mercury-enriched ore deposits developed by underground working, acid mine drainage may be an important source of mercury and methyl mercury. The concentration in mine drainage is dependent on the type of ore deposit associated with the drainage, and whether the mine drainage has reacted with mine wastes. The reaction of mine drainage with mine wastes can increase the concentration of both mercury and methyl mercury in mine drainage and is can be an important process that controls the release and transport of both mercury species from mine sites.

In general, mining operations can be large sources of mercury for many years after mining has been discontinued. Mercury may be transported by riverine flow as a result of erosion of mercury contaminated soils and sediments. Rivers can carry mercury in dissolved and particulate form for hundreds of kilometers to marine ecosystems. Significant amounts of elemental mercury from such areas are also emitted to the atmosphere, which can be spread over long distances and contribute to the global mercury pool. The deposition of mercury away from such local sources can result in the remobilization of mercury that is available for methylation. Hence, secondary sources of toxic forms of mercury can be produced at great distances from the original source.

Various ore-processing methods, such as roasting and smelting of ores (primary mercury mining or other metal mining using high temperature processes), may release mercury species to the atmosphere, which are partly deposited locally. This release may result in areas around processing plants becoming contaminated sites.

Artisanal and small-scale gold mining

A comprehensive summary of Artisanal Small-scale Gold Mining (ASGM) is provided by Telmer & Veiga (2008). Mercury in artisanal gold mining is used to form an amalgam that binds with gold. The magnitude of loss of mercury and ways it is released from a specific site are defined by the separation procedures to remove the gold from the amalgam. When mercury is used to amalgamate gold, some escapes directly into water bodies as elemental mercury droplets or as coatings of mercury adsorbed onto sediment grains. The mercury that forms the amalgam with gold is emitted to the atmosphere when the amalgam is heated unless a fume hood or retort is used. In addition to the deliberate use of mercury to extract gold, naturally occurring mercury in soils and sediments that are eroded by sluicing and dredging becomes remobilised and bioavailable in receiving waters (Telmer et al. 2006). Finally, where a combination of cyanide and mercury are used, the formation of water soluble cyano-mercuric complexes enhances transport and bio-availability. Similarly to the industrial scale mining operations, contaminated soils and sediments following ASGM activities can be large sources of mercury for many years after mining has been discontinued. Mercury may be transported by riverine flow as a result of erosion of mercury contaminated soils and sediments.

Most of the ASGM activity takes place in developing countries and countries with economies in transition and very often miners are not aware of the health risk connected to the activities.

Chlor-alkali industry

Approximately 150 chlor-alkali plants were in operation worldwide in 2004. However, in Europe many plants have closed or are going to be closed in few years due to recent legislation (Concorde East-West, 2006). Most chlor-alkali plants use mercury cell technology but with processes that differ substantially from country to country (Eurochlor, 2007). Several studies have shown that mercury in the vicinity of chlor-alkali plants exceed background values up to a factor of 50 to 80. It was calculated that 5-10 % of mercury emitted from the plant was retained in the soils around the plants, the rest being subject to long range transport. According to Biester et al. (2002) 25% of Hg deposited to soils around chlor alkali plants is reemitted within a short time. Without the proper remediation actions the abandoned and shifted sites remain a significant source of mercury for many years.

Landfills and waste dumping

In Western Europe, almost 50% of the products containing mercury end up in landfill, Landfills or dumping can therefore be considered as a significant source of mercury emissions.

Other mercury sources in the environment

Potential elevated mercury exposure can occur also in the following areas and should be addressed with great care.

Land and water management practises may change the mobility of mercury. In reservoirs, elevated levels of mercury may occur following the initial flooding, which may result in very high levels in the local fish population. These elevated levels may be observed for up to 40 years. Deforestation often leads to increased erosion. Deposition of soil in waterways can result in the release and methylation of mercury in these waters, leading to high levels in fish. Where forests are cleared by burning, elevated levels of mercury may be released into the environment. Populations living downstream of deforested areas may therefore be at risk from high levels of mercury in the fish.

Managing hot-spots

Priorities must be established when identifying and characterising hotspots. Factors which must be considered include the size of the hotspot, chemical and biological characteristics of the hotspot, contact with drainage, possibility of mercury mobility, possibility for mercury methylation/demethylation/reduction, quantity and vulnerability of biota being affected and the risk of affecting people.

In the initial stage it is important to find answers to the following questions: How many people live there? How was mercury released and used? How much mercury was released? What are the possibility for mercury mobility and transport? What are the risks?

In addition other important issues related to climate and hydrology, land use, and other social and economic factors such as possible trans-boundary movement should be considered in the assessment.

Analytical methods for the determination of mercury and its species in environmental (water, air soil, sediments) and biological samples have been developed and are available. These methods normally involve numerous steps prior to quantification such as sample collection, sample pre-treatment, preservation, and storage. It is essential to have a good quality assurance programme and skilled staff. Protocols are needed to prevent contamination or loss of mercury, as well as transformation into other species of mercury. Methods for the determination of total and major species of mercury are selected depending on the nature of the sample and in particular on the concentration levels of mercury. In addition to sophisticated laboratory methods, robust and simple methods recently become available for the characterisation of contaminated sites.

Protocols and guidelines for characterisation of contaminated sites are currently not existent. A protocol for environmental and health assessment in artisanal and small scale mining prepared under the GEF/UNIDO Global mercury programme is useful and may serve as a good basis for further development of guideless commonly applicable to all contaminated sites.

Extent of contaminated sites

Altogether, we identified more than 1200 sites where mercury ore was mined and/or processed, 220 sites where mercury has been used in the chlor-alkali industry (both active and converted plant were taken into account), approx. 500 locations where precious metals (gold and silver) are processed in the large-scale mining activities and more than 600 locations where non-ferrous metals ore is processed (including zinc, copper, lead and nickel). As Artisanal Small-scale Gold Mining (ASGM) activities are conducted at hundreds of small sites they are considered as point sources, and cannot be individually identified. The estimates of mercury releases from ASGM activities were based on country data from the report of Telmer and Veiga (2008).

From a global perspective, most of mercury contaminated sites identified (> 70%) are concentrated in industrial regions of Europe and North America that are adjacent to the Atlantic Ocean and Mediterranean Sea. In contrast to Europe and North America, the number and extent of mercury contaminated sites in other parts of the world (especially Asian countries and India) are increasing due to rising use of mercury in various products and processes.

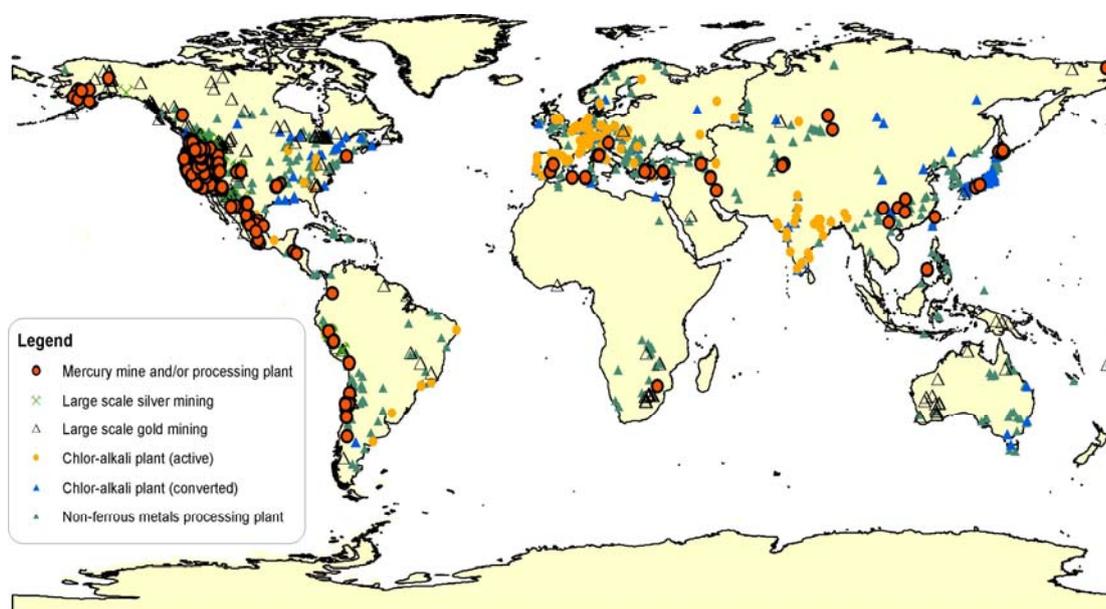


Figure 1: Global distribution of mercury contaminated sites

The contribution of contaminated sites to global mercury budget

In the last decade, a lot of effort was made to assess global mercury releases from other natural and anthropogenic sources. This study has made a first preliminary attempt to assess the relative importance of mercury contaminated sites in the global mercury budget. It is extremely difficult to separate direct emissions which are included in the UNEP global emissions report (UNEP, 2008) from emissions attributed from contaminated sites. It is possible therefore that there could be some duplication in the estimates. In the assessment, different ways of mercury transport away from such sites were considered. Due to its volatile nature, significant amounts of elemental mercury from such areas are re-emitted to the atmosphere. Another way of transport is by hydrological means, including drainage and riverine flow.

Among different sources and uses of mercury, mercury mining, precious metal processing, non-ferrous metal production and various polluted industrial and urban sites were recognized as the most important source categories resulting in mercury contaminated sites, while the chlor-alkali industry is regarded in this assessment as a separate source category within contaminated industrial sites.

How to estimate emissions?

The estimates on mercury releases and the extent of mercury contaminated sites presented are backed by up-to-date literature results. Based on the available data, different approaches were used when estimating the contribution from individual source categories. Atmospheric mercury emissions from primary mercury mining sites were estimated based on the fluxes reported in the literature from such sites and the number of sites (Figure 1). In the calculation, different flux values for point (in the vicinity of sites) and dispersed non-point sources (area of ~3 km² around these sites) were considered. Mercury releases to aquatic environments from these sites were estimated based on the ratio of mercury lost to the atmosphere, as measured from the case studies. Similar, atmospheric mercury emissions from contaminated sites surrounding chlor-alkali plants were estimated based on the emission ranges reported in the literature for such sites and the number of plants identified (Figure 1). Again, different emission values were used for point sources adjacent to the enterprises (e.g. mercury containing waste) and surrounding dispersed non-point sources (1-2 km²). Mercury contribution to aquatic environment from chlor-alkali plants was assessed based on available historical releases reported in the literature. In the assessment of mercury releases to the atmosphere from non-ferrous metal production sites, the number of processing plants identified globally (Figure 1) and the fluxes reported in the literature within ~2 km around these sites were taken into account. For estimation of mercury releases to the atmosphere from the large-scale precious metal (gold and silver) processing, mercury fluxes from mine wastes surrounding these sites reported in the literature and their number (Figure 1) were taken into account, while releases to aquatic environments were estimated based on the reported mercury losses to environment during the history of mining. The estimates for atmospheric re-emissions from artisanal and small scale gold mining (for 70 counties worldwide) were taken directly from the report of Telmer and Veiga (2008). A mercury release to aquatic environments from this category was estimated based on the riverine fluxes reported in the case studies and reported mercury global consumption in the ASGM process. In addition, under category other industrial and urban sites, a rather rough estimate of mercury contribution to atmosphere was made for identified sites, based on the magnitude of mercury fluxes reported in the literature from such sites.

Estimated emissions from contaminated sites

Summing up the contribution of mercury to both the atmosphere and hydrosphere, about 150-300 metric tonnes of mercury is released annually to the global mercury budget from identified mercury contaminated site categories. Based on this the annual contribution of mercury to the atmosphere from contaminated sites is something less than 5% compared to the global anthropogenic atmospheric emissions as reported by UNEP (2008). On average, more than 50% of the atmospheric contribution from contaminated sites comes from precious metal processing (both large scale and ASGM), followed by mercury mining and polluted industrial/urban sites, respectively, non-ferrous metal processing and chlor-alkali industry.

Our current estimates of mercury releases to the hydrosphere due to the erosion of soils and sediments from contaminated sites indicate that these releases can be of paramount importance and are in the same order of magnitude as the atmospheric ones. Among contaminated sites contributing mercury to the hydrosphere, precious metal processing and mercury mining were identified as the most important categories. Mercury released in the hydrosphere ultimately ends in seas and oceans as a consequence of riverine transport. Considering that the majority (~90%) of mercury load in rivers deposits around the river mouth and on the continental shelf, it was estimated that up to 20 metric tonnes yr⁻¹ of mercury from contaminated sites reaches the open ocean. Even more important, in terms of mercury contribution from contaminated sites, is the fact that a big part of contaminated sites is located at or near the coastline. Much of the mercury containing products industry (e.g. >40% of all chlor-alkali plants) located at the coast have for decades introduced waste containing mercury directly into local estuaries. Based on the published data on historically mercury releases to the estuaries in this way, we estimated the amount on the order of 1000 metric tonnes of mercury accumulated in these contaminated estuaries. Assuming that only 0.1 % of this burden is redistributed by currents every year, additional several tonnes of mercury can be expected to be released to open oceans from these contaminated sites.

Table 1: Total mercury emissions to the atmosphere (A) and hydrosphere (H) from contaminated sites.

	Atmosphere (t yr ⁻¹)	Hydrosphere (t yr ⁻¹)
Mercury mining	5-20	10-50
Chlor-alkali industry	1-3	2-5*
Non-ferrous metal processing	1-5	-
Precious metal processing (large scale)	2-10	5-10
Artisanal and small scale gold mining (ASGM)	50	50-100
Other industrial and urban sites	10-20	-
Total	70-110	70-165
Total (A+H)	140-275	

* due to the historical accumulation of Hg releases to water from CAPs, global accumulation of mercury in the estuaries of an order of 103 is estimated from this category alone

It must be noted, however, that the data above are associated with large uncertainties, due to scarcity of data on mercury releases from contaminated sites and our extrapolation of emissions data from selected case studies located in different meteorological and topographic areas. The uncertainty is much larger in the case of estimated releases to the hydrosphere, compared to atmospheric emissions for which more data is available.

Although mercury contaminated sites contribute only a few percent to the global mercury budget, these sites should be considered very carefully. Compared to active anthropogenic point sources of mercury emission, mercury contaminated sites represent a long-term source after the specific activity discontinued. The release and transport of mercury away from such sources can result in the significant negative impacts in the environment and human health far away from the original source. Understanding and modeling mercury transport and fate from contaminated sites require detailed understanding of physico-chemical behaviour of mercury.

A concerted action between a development of a geo-referenced database of mercury contaminated sites with on-site ad-hoc flux measurements will certainly improve future estimates. A specific concern is for regions that are inadequately described in terms of point sources (Africa, South America) or exhibit unusually large uncertainties (Asia). Atmospheric mercury models developed in recent years for assessing the relationship between emission source regions and receptor regions are useful tools in the work to assess mercury effects. However, models are simplification of reality and exhibit limited accuracy. Models require accurate data, and the accuracy of current models is severely limited by the lack of a unified global emission inventory that accounts for a better emission source characterisation and monitoring/observational data.

The risks to public and environmental health of mercury compound releases from contaminated sites

The recent UNEP/WHO publication "Guidance for identifying populations at risk from mercury exposure" (IOMC, September 2008), summarizes risks of mercury exposure to public health in general and provide guidelines for identification of population at risk.

People living in contaminated sites are exposed to elevated levels of mercury, frequently exceeding safe levels. The release of mercury to the environment from mineral deposits enriched in mercury can impact humans and biota through direct and indirect pathways. Direct pathways include ingestion of tailings and soils contaminated with mercury and respiration of mercury vapour and enriched particles. Ingestion is primarily a concern for young children that may eat soil directly, or be exposed by a high level of hand-mouth activity. Indirect pathways that impact humans are more important and include consumption of fish and, more rarely edible plants that have been contaminated with methyl mercury.

The factors that determine the occurrence and severity of adverse health effects include: the chemical form of mercury; the dose; the age or developmental stage of the person exposed (the fetus is considered to be the most susceptible); the duration of exposure; and, the route of exposure (inhalation, ingestion, and dermal contact). Dietary patterns can increase exposure e.g. in a fish-eating population when fish and seafood are contaminated with mercury.

The primary targets of toxicity of mercury and mercury compounds are the nervous system, the kidneys, and the cardiovascular system. It is generally accepted that developing organ systems (such as the fetal nervous system) are the most sensitive to toxic effects of mercury. At the same time, studies have indicated that levels of mercury in a fetal brain appear to be significantly higher than those in maternal blood. Other systems that may be affected include the respiratory, gastrointestinal, hematologic, immune, and reproductive systems.

Although the toxic nature of mercury is well acknowledged, little is known on the effects of mercury on humans as a consequence of long-term exposure to low concentrations, which are often seen in contaminated sites. In many cases, the use of biomarkers, such as Hg concentrations in blood and urine, are not sufficient to assess the internal doses and potential effects on the central nervous system, kidney, the immune system, and other possible effects. Therefore, better scientific understanding of risks to human health, especially to those citizens living close to potentially polluted sites, is needed.

In addition, there are many important gaps in defining the benchmark dose for significant effects due to uncertainties associated with epidemiological studies carried out so far:

- Exposure assessment is imprecise. In the case of methyl mercury, calculation of the intake is complex because it is based on the conversion of biomarker data such as hair levels into daily intake.
- The effect of a single factor has been assumed (in this case a single mercury form) in a situation where many covariates may affect the final impact. There are a large number of potential confounding factors in major epidemiological studies on methyl mercury, such as the source and pattern of methyl mercury exposure (or elemental mercury exposure), the nature of the populations, the influence of nutrition, and the presence of other pollutants such as PCBs, which make comparison of the studies and interpretation of the data difficult.
- In numerous contaminated sites/regions, humans are simultaneously exposed to elemental mercury through inhalation, and to inorganic mercury and methyl mercury through food consumption. So far, very little is known of the effects of these combined exposures on adults and children. Further studies are needed to develop safe limits of exposure for the most vulnerable groups.

Most human health related studies in contaminated sites were carried out in mercury mining areas (Slovenia, Spain), chlor alkali sites (Kazakhstan, Albania, Italy and Sweden) and artisanal gold mining sites (GEF-UNIDO project). Unfortunately, these studies mainly addressed exposure. Risk characterization, however, is the integration of the hazard identification, dose-response assessment, and exposure assessments to describe the nature and magnitude of the health risk. Risk characterisations of the relevant populations in the above mentioned studies have not been addressed adequately. This prevented the development and implementation of effective programmes to protect the populations.

Limited information on exposure to mercury in contaminated sites is available. Exposure to methyl mercury has recently been addressed by numerous groups as a consequence of long-range transport, deposition and availability. A few studies implemented in contaminated sites indicate that direct exposure to elemental, inorganic and methyl mercury in contaminated sites significantly exceed the background areas and contribute to the exposure of wildlife. It is documented that wild fish mammals, and birds, that live on fish, may be at risk for elevated dietary methyl mercury intake and toxicity. In controlled feeding studies, a diet that contained mercury (as methyl mercury) at environmentally realistic concentrations resulted in a range of toxic effects in fish, birds, and mammals, including behavioural, neurochemical, hormonal, and reproductive changes. Limited field-based studies support laboratory-based results demonstrating significant relations between methyl mercury exposure and various indicators of methyl mercury toxicity, including reproductive impairment (Sheuhammer et al., 2006).

Very limited information is available on the effects of mercury released from contaminated sites on candidate wildlife species. Limited (but useful) guidelines for ecosystem response to mercury contamination is available (Harris et al. 2003), but these are commonly not included and implemented in the monitoring strategies, particularly for existing contaminated sites. Further development of monitoring strategies is needed to improve the knowledge and prevent negative impacts.

Environmentally sound mitigation options and costs

Given the unique behaviour of mercury, remediation of mercury-contaminated sites can be complicated and costly. Commonly employed and emerging techniques to mitigate mercury pollution include well-established ex-situ (external) techniques, such as physical separation and thermal treatment of excavated materials, and in-situ (i.e. in place) mercury recovery methods, such as soil vapour extraction combined with soil heating and the use of leaching agents. In addition, containment strategies for sites where more conclusive measures cannot be employed are also available.

Many factors are used to assess the suitability of specific remedial measures for a given site. The distribution and properties of soil and rock and a comprehensive understanding of the site hydrogeology and hydrology, are used in conjunction with physio-chemical properties of the contaminant to predict mobility and distribution and subsequently develop means for mitigation.

The determination of clean-up goals and prescribed responses are dependant on identified risks to human and ecological health. Although numerical criteria are valuable indicators of the occurrence and extent of contamination, these levels are not economically or technically attainable in some situations. If mercury is detected in biota (i.e. it is bioavailable) or the risk of its subsequent incorporation into organisms is appreciable, then more aggressive and often more costly measures are warranted.

In the case of dispersed mercury contamination, remedial measures are typically not feasible. If bioaccumulation is identified, then exposure pathways must be addressed. Possible responses include the implementation of dietary advisories to reduce intake of contaminated food, adaptation of natural resource management practises (water and land) to reduce bioavailability of mercury for man and ecosystems and educational programs to lessen exposure to mercury. If mercury is distributed in a well defined area and bioaccumulation is evident, then remedial actions are warranted. If the potential for assimilation into the food chain is low, then containment methods are sufficient. In either situation, long term management is required until adequate protection of ecological and human health is ensured.

Conclusions

This study confirmed that it is difficult to develop robust data on extent of contaminated sites and/or quantification of releases/pollution due to limited data available. Total mercury emissions to the atmosphere and hydrosphere from contaminated sites are estimated to be between 150 to 300 metric tonnes per year. Both the atmospheric mercury emissions and mercury inputs and distribution in the aquatic environment depend strongly on the climatic conditions and the topography of the site in question. Therefore, extrapolations from a few well studied cases are associated with large uncertainties.

Although, releases from contaminated sites contribute a relatively small proportion of current anthropogenic sources annually (atmospheric releases are currently less than 5% of the global anthropogenic atmospheric emissions as reported by UNEP (2008)), the estimated releases demonstrate that it is not an insignificant source. In addition, it should be mentioned that these secondary mercury sources will emit mercury for a very long time, if not managed properly and/or remediated. Inappropriate land and resource management of contaminated sites may further increase these releases resulting in an increased risk for local populations and ecosystem. Remediation of such sites can be expensive, and decisions on when to treat are complex.

Impacts on local populations may be disproportionate to overall global impacts. Studies implemented in some selected cases indicate severe exposure especially in sensitive members of the population. Unfortunately risk characterisations in studies carried out at contaminated sites have not been addressed adequately. Further studies are therefore needed for the development and implementation of effective programmes to protect the populations residing in or near mercury contaminated sites.

Due to large uncertainties in the assessment of mercury releases from contaminated sites and its potential long-term impact on health of humans and ecosystems, there is a need for an integrated approach for the management of contaminated sites. These should cover all areas, including guidelines for characterisation and remediation of contaminated sites.