

10 Data and information gaps

992. This chapter is intended to characterise the main categories of data gaps identified for improved risk assessment and risk management with regard to mercury. As such it does not attempt to give a full list of detailed data gaps in the different fields of research.

10.1 National research and information needs

993. A number of countries have in their submissions to UNEP expressed a need for establishing or improving their national “database” (i.e. knowledge of and information on uses and emissions, sources of releases, levels in the environment and prevention and control options) on mercury and mercury compounds. Although the situation varies from country to country, there seems to be a general need for information relevant to the various elements of an environmental management strategy for mercury. Also countries with a longer tradition of environmental management of mercury have expressed the need to continue to expand their knowledge base on mercury to improve risk assessment and ensure effective risk management. Some of the needs include, among others:

- Inventories of national use, consumption and environmental releases of mercury;
- Monitoring of current levels of mercury in various media (such as air, air deposition, surface water) and biota (such as fish, wildlife and humans) and assessment of the impacts of mercury on humans and ecosystems, including impacts from cumulative exposures to different mercury forms;
- Information on transport, transformation, cycling, and fate of mercury in various compartments;
- Data and evaluation tools for human and ecological risk assessments;
- Knowledge and information on possible prevention and reduction measures relevant to the national situation;
- Public awareness-raising on the potential adverse impacts of mercury and proper handling and waste management practises;
- Appropriate tools and facilities for accessing existing information relevant to mercury and mercury compounds at national, regional and international levels;
- Capacity building and physical infrastructure for safe management of hazardous substances, including mercury and mercury compounds, as well as training of personnel handling such hazardous substances;
- Information on the commerce and trade of mercury and mercury-containing materials.

International information exchange and national efforts to collect information

994. In principle, some parts of this information might be exchanged nationally, regionally or internationally, as its relevance is often universal, however, it might need to be “translated” into the context of the individual country’s framework of traditions, economic and industrial activities and political reality. This, in itself, demands a substantial degree of priority, knowledge and funding.

995. The assessment process undertaken by UNEP through Governing Council decision 21/5 and the data collected and presented in this connection (reports, documents, web-page) in itself contributes to such information exchange – other additional information exchange activities might also be considered. No doubt, large amounts of basic knowledge on mercury have been generated, and progressively more information is becoming globally available thanks to national, regional and international efforts. Furthermore, the speed of the information exchange is increasing as more and more information on mercury and other hazardous substance becomes available via the Internet.

996. Other parts of the information are country specific and would require national efforts to re-search, collect and process the information necessary to establish national action plans/strategies on mercury within the context of their national environmental management scheme.

997. A number of countries have developed strategies to promote research and information generation activities to fill identified information gaps or generate further information to support their mercury risk assessment and management activities. A few examples include the Mercury Research Strategy issued in September 2000 by the US EPA (sub-5-gov) and the COMERN (Collaborative Mercury Research Network) research programme on the impacts of atmospheric mercury deposition on large scale ecosystems in Canada, supported by the Canadian government (sub-5-ngo). A number of national and regional mercury action plans also contain sections describing concrete activities to fill data and information gaps.

10.2 Data gaps of a general, global character

998. In addition, although mercury is probably among the best-studied environmental toxicants, there are data gaps in the basic understanding of a number of general, global issues relevant to mercury.

999. Based on submitted information and the compilation and evaluation hereof, a possible division of current data gaps of global relevance on mercury could be as follows (not in order of priority):

- Understanding and quantification of the **natural mechanisms affecting the fate of mercury** in the environment, such as mobilisation, transformation, transports and intake. In other words, the pathways of mercury in the environment, and from the environment to humans.
- Understanding and quantification – in a global perspective – of the **human conduct in relation to mercury releases**, and the resulting human contributions to the local, regional and global mercury burden. In other words, the pathways of mercury from humans to the environment.
- Understanding of how and to what degree humans, ecosystems and wildlife are **adversely affected by the current mercury levels** found in the local, regional and global environment. In other words, the possible effects, number affected, and the magnitude and severeness in those affected.

Basic understanding

1000. A basic understanding has been established for all three categories mentioned above, based on about half a century's extensive research on the impacts and pathways of mercury. However, in a number of areas, further research is needed to provide new information to improve environmental modelling assessments and modern decision-making tools.

Quantification of origins, pathways and impacts of mercury

1001. In order to manage environmental toxicants like mercury efficiently and cost-effectively, a substantial level of quantification of origins, pathways and impacts is necessary. The question of which level of certainty of evidence is considered required as a basis for abatement actions is, however, basically political – a set of priorities in the span of public health, environmental quality and socio-economic possibilities. The traditions and political priorities on these aspects vary among countries and regions, and develop over time.

1002. However, as an example, Canada expressed in their comments to the first draft of this report (comm-24-gov):

“..., there are numerous areas where additional knowledge is required, for example in the areas of biochemistry, atmospheric sciences, hydrology, toxicology/epidemiology, monitoring strategies for mercury levels in biota, and the collection of information on mercury levels in fossil fuels. However, while it is important to be aware of outstanding questions, the existing evidence clearly dem-

onstrates that there are risks to the environment and human health associated with mercury exposure. Therefore, it is not realistic to delay the process of the assessment and options development until we have all the answers.”

Summary of identified data gaps

1003. The following sections provide a summary of the types of data gaps mentioned in submissions and comments to the first draft of this report, as well as gaps identified in the preparation of this report. For more details, see references given below.

10.2.1 Examples of data gaps on natural mechanisms affecting the fate of mercury

- Further studies of natural emissions of mercury would be useful in order to minimise uncertainties in their quantification and describe better the relative importance of human mercury contributions. In particular, information is needed on the location of main natural emission areas and quantification of seasonal and annual variations of the emissions in addition to the total amounts, as well as separation of area sources (e.g. from areas with mercury-mineral containing soils and bedrock) and point sources (e.g. volcanoes and fumaroles). Mercury is also emitted from ocean surfaces and the natural component of these emissions cannot be distinguished from re-emissions of previously deposited mercury. In this case, the total emissions to the atmosphere should be determined. In all cases, determination of speciation of mercury emitted from natural sources is of importance, including identification of elemental mercury, oxidised gaseous mercury and methylated mercury (i.e. mono- and dimethylmercury) (see for example submission from Canada, sub-42-gov).
- Further studies would be useful in order to improve the understanding of transport, transformation and fate of mercury in the atmosphere and in aquatic and terrestrial media, with particular focus on:
 - 1) Improvement of the quantitative understanding of the dynamics of mercury transformations and deposition processes in the atmosphere, including the Polar Mercury Depletion Events and oxidation/reduction processes in the free troposphere, laboratory and field investigations of oxidation/reduction processes, dry deposition and gas-liquid exchange processes;
 - 2) Determination of processes that control the mobilisation/immobilisation of mercury in soils and sediments, with main focus on leaching of mercury and methylmercury from forest soils to aquatic systems;
 - 3) Quantification of methylation/demethylation processes in aquatic ecosystems with specific focus on Arctic and coastal ecosystems and processes where oxidised mercury is reduced and released to the atmosphere and identification of the main pathways of methylmercury uptake in aquatic foodchains, with focus on Arctic and coastal ecosystems;
 - 4) Development and refinement of models describing chemical processes, dispersion and long-range transport of mercury, with special focus on hemispherical and global scale models, in order to facilitate quantitative descriptions of the global atmospheric cycling of mercury; and development of ecosystem models for mercury including mobility and bioaccumulation in terrestrial and aquatic ecosystems;
 - 5) Encouragement of technology transfer and international cooperation on standardising sampling and analytical methods for mercury species.
- Further studies of methylation, biomagnification and other processes and interactions in the food webs would be useful in order to describe better (e.g. in quantitative models) the links between human releases of mercury and observed concentration levels and impacts on humans, ecosystems and wildlife, (see for example submissions of Canada (sub-42-gov), COMERN (sub-5-ngo), Switzerland (sub-38-gov), Germany (sub-57-gov) and Thailand (sub-53-gov)).
- Further studies of chemical reaction constants and other mechanisms affecting the transformation and fluxes of mercury in and between gaseous, liquid and solid phases in the atmosphere, as well as between the atmosphere and the aquatic and terrestrial environmental compartments, would help to

improve modelling of local, regional, hemispherical and global atmospheric transport of mercury, and better understand the global mercury cycle, (see for example submission of Italy/EU, sub-52-gov).

- Further measurements and assessments of re-emission of formerly deposited mercury from land and water surfaces might be needed to improve understanding of the global mercury cycle, including atmospheric long range transport and the relative importance of anthropogenic contributions, as well as enhancing possibilities for modelling and monitoring changes due to emissions reductions, (see for example submission of Italy/EU, sub-52-gov).
- Further studies of the evidence of the accumulated historical mercury contributions of humans to the environment, would be useful in order to describe better the relative importance of human impacts, (see for example submission of Canada, sub-42-gov).
- Further monitoring of the role of dry deposition of mercury would be useful in order to gain a better understanding of the relative contribution of wet versus dry deposition.

10.2.2 Examples of data gaps on human conduct in relation to mercury

- Further improvement and updating of assessments of global anthropogenic consumption, mobilisation, flows and releases of mercury (including atmospheric emission inventories, releases from waste treatment releases to aquatic environments etc.) would be useful in order to give a more complete picture of the situation and a better basis for selecting – on a global basis – which human sources should be addressed (and how), if reduction of human mercury releases are prioritised, (see for example section 6 and 7, submissions of the European Commission (sub-40-gov), Italy/EU (sub-52-gov), Switzerland (sub-38-gov), and comments from USA (comm-24-gov).
- Assessment of expected changes in global consumption and corresponding supply of mercury for different possible prevention/reduction scenarios would be useful in order to give a basis for decisions on management of supply (production, recycling and stocks management), in case this is prioritised, (see for example submission of the Nordic Council of Ministers, sub-84-gov).
- While it has been possible to assemble a reasonably complete picture of commodity stocks and flows among industrialised countries, the decreasing economic importance of mercury has been accompanied by a corresponding decline in public availability of production and use information. Moreover, an increasing share of mercury production and use occurs in developing countries, and as such, is little reported. Finally, many countries are unaware of flow analysis techniques. Specific data gaps, including those for mercury production and use, include:
 - 1) Annual basic production and use figures to allow for monitoring of programme success in reduction efforts, including such information as compiled by USA Geological Survey's annual "Mineral commodity surveys";
 - 2) A baseline economics study of primary virgin mining of mercury to provide insight into price-responsiveness of mines. Examples of information to be obtained include: legal status, ownership, relevant environmental regulation, per-unit cost of production, the nature and extent of public subsidies and annual production and sales since 1990;
 - 3) A periodic inventory of uses to guide future demand-reduction efforts, including an exhaustive list of specific uses (products and processes) and quantitative estimates of current use and characterisation of future demand for major end-use categories;
 - 4) A periodic inventory of non-market demand factors to support future demand projections, including a list of mandatory phase-outs/bans;
 - 5) A baseline survey of artisanal mining, including the quantity of gold mined, the number of miners and the quantity and rate of mercury used;
 - 6) Available techniques to perform materials flow analyses (MFA, SFA) in all industrial sectors need to be transferred and applied internationally.

- Improvement of emission inventories for anthropogenic emissions, including speciation of mercury, would be useful. Special attention should be paid to diffuse emissions from handling of elemental mercury (e.g. artisanal gold mining), household and uncontrolled waste incineration, as well as improvement of data from main point source categories (industries handling mercury, waste incinerators and power plants using fossil fuel).
- Further studies of mercury content in fossil fuels (coal, natural gas and petroleum) and the chemical and physical mechanisms and combustion conditions that influence mercury in a combustion system would be useful in order to obtain a better understanding of the contribution of fossil fuel combustion to the global mercury cycle and to determine effective approaches to reduce emissions from this source. In addition, it would be useful to improve emission inventories for major anthropogenic sources with emphasis on feedstock (e.g. coal), process configuration (e.g. boiler design), emission control design and operation, and by-product use/disposal.
- Development and demonstration of integrated multi-pollutant (SO₂, NO_x, particulate material and mercury) control technology and continuous emission monitors would be useful.
- Development of information on good practices in prevention and control technology for cement production, conventional and artisanal mining, metallurgical industries and chlor-alkali plants would be useful for many countries.
- Further studies to develop commercially viable substitutes for those mercury product applications that still remain would be useful in order to reduce (and eliminate) intentional use of mercury in products and ultimately remove mercury from the waste stream.
- Development of a product substitution manual to be made available to many countries would be useful.
- Assessment of economic and social burdens and benefits of different possible prevention/reduction scenarios for mercury would be useful in order to give a better basis for selecting on a global basis which human sources should be addressed, if reduction of human mercury releases are prioritised.
- Further research on the interim and definitive storage of excess mercury and mercury-bearing waste would be useful in order to be able to permanently remove surplus quantities of mercury from society. Such storage solutions need to be monitored and retrievable, and should assure that the repository is maintained in a way that minimises emissions by all routes to the greatest extent possible. The transfer of mercury from society to such repositories must be conducted under occupationally safe conditions.

10.2.3 Examples of data gaps on adverse effects of current mercury levels

- Improvement of the understanding of dose-response relationships for methylmercury, elemental and inorganic mercury and their dependence on individual vulnerability, whether due to life-stage, nutrition, or other factors would be useful. In regard to methylmercury, information gaps include the possible impact on cardiovascular disease and mortality.
- Further research on the potential for health impacts of dental amalgam and vaccine additives containing mercury compounds would be useful.
- Coordinated and expanded monitoring of mercury concentrations in human hair and other relevant human samples would be useful in order to allow better definition of populations at risk from increased exposure. Such monitoring may also be used as a tool for prioritizing prevention actions on a local scale.
- Improvement of the understanding of the effects of co-exposure to different mercury species (and via different exposure routes) on dose-response relationships for humans would be useful.
- Further studies to improve the understanding of which – and how serious – ecotoxicological effects mercury currently has on different types of ecosystems and wildlife, in a global perspective, would be useful. For example, a growing body of evidence suggests that certain highly exposed wildlife

species are at risk from exposure to mercury through consumption of contaminated fish and shellfish. Key data gaps include an improved understanding of toxicological effects and ecological impacts of methylmercury on various species; interaction of mercury with other chemical and non-chemical stressors on ecological receptors; and ecological risk assessment methods.

- Development of practises for international coordination of monitoring of various environmental media would be useful.
- Assessment of environmental benefits and burdens of different possible prevention/reduction scenarios for mercury would be useful in order to give a better basis for selecting – on a global basis – which human sources should be addressed, if reductions of human mercury releases are prioritised (relates also to the issue of human conduct in relation to mercury).

10.2.4 Future use of information collected for the Global Mercury Assessment

1004. As mentioned several times in this report, a vast material has been submitted for use in this process and a network of contacts at national, regional and international levels have been established. Besides the benefit already derived from this material, it might also form part of a basis for further elaboration on several of the issues mentioned above, as well as other issues relevant to the global environmental implications of mercury, if such work would be deemed beneficial.

10.3 Development of Policy Tools

1005. On the basis of the summary provided in previous sections of this report on the complexity of chemical and physical mechanisms involved in the mercury cycle, one may wish to ask several questions, including the following: (see also Pirrone 2001; Pirrone *et al.* 2002) What are the qualitative and quantitative relationships between atmospheric input, deposition and mercury in aquatic environments? Is it possible to establish a deposition limit for mercury in order to regulate its emissions to the atmosphere? Do we know the relationship between the flux of mercury entering surface waters and the level of mercury (methylmercury) found in fish? Is it possible to evaluate the response time of the marine ecosystem in relation to changes in atmospheric emissions? Are any regional/hemispherical modelling frameworks validated and tested for assessing temporal and spatial patterns of mercury deposition to marine waters and its subsequent accumulation in the fish and ultimately its impact on the food chain?

1006. To help answer these questions and to assist the development and/or implementation of international strategies aiming to reduce the impact of mercury on human health and the environment, there is a need to develop policy tools that would help policy makers and different type of users and stakeholders to select the most cost-effective strategies.

1007. As an example, in Europe the Directorate General (DG) for Research of the European Commission is supporting mercury research programmes (i.e., MERCYMS) aimed to develop integrated modelling tools based on the concept of the Drive-Pressure-State-Impact-Response (DPSIR) framework, which has been used already as basis for the European Air Quality Directive on Ozone. Similar exercises aimed to develop integrated modelling tools are underway also elsewhere (i.e. USA, Canada).

1008. Figure 10.1 provides a conceptual DPSIR for mercury pollution reduction and control, as described by DG Research, where it is shown how our understanding of pressure factors interact with other areas of environmental knowledge such as impact assessment and monitoring (State), economic activity (Driver) and effective environmental policy (Response). A better assessment of a *spatial resolved emission inventories* play an important role in assessing the effects of anthropogenic activities on terrestrial and aquatic environments. The principal human demands for i.e. energy, transportation and food may be regarded as the "Drivers" for the production of mercury emissions to the ambient air. In order for an economy to continue to develop in a sustainable way, these sources of pollution must be managed. To do this we need to understand the "Impacts"- *i.e. what types of pollution affect which parts of the environment or human health*, and to what extent they do so. To decide whether action is necessary it is also helpful to know the "State" of the environment *i.e. evaluate whether the levels in the envi-*

ronment exceed those which will cause environmental harm. In taking appropriate action we must be able to respond in a focused way to prevent, control and reduce pollution while avoiding larger-scale damage to economic development. Emission inventories provide policy makers and the public with an understanding of the key polluting sources or the "Pressures", how these sources have developed with economic growth and how they are likely to contribute to pollution in the future. This understanding is essential for a focused "Response" to the problems associated with mercury pollution and to meet the demands of sustainable development. The Policy Response may refer to socio-economic scenarios with different Targets of mercury pollution control (i.e. BAU: Business as usual scenario; POT: Policy target scenario; DG: Deep green scenario,).

1009. Like mentioned in section 10.2 above, initiation of policy actions does not always require a full, detailed understanding of all elements of the conceptual framework.

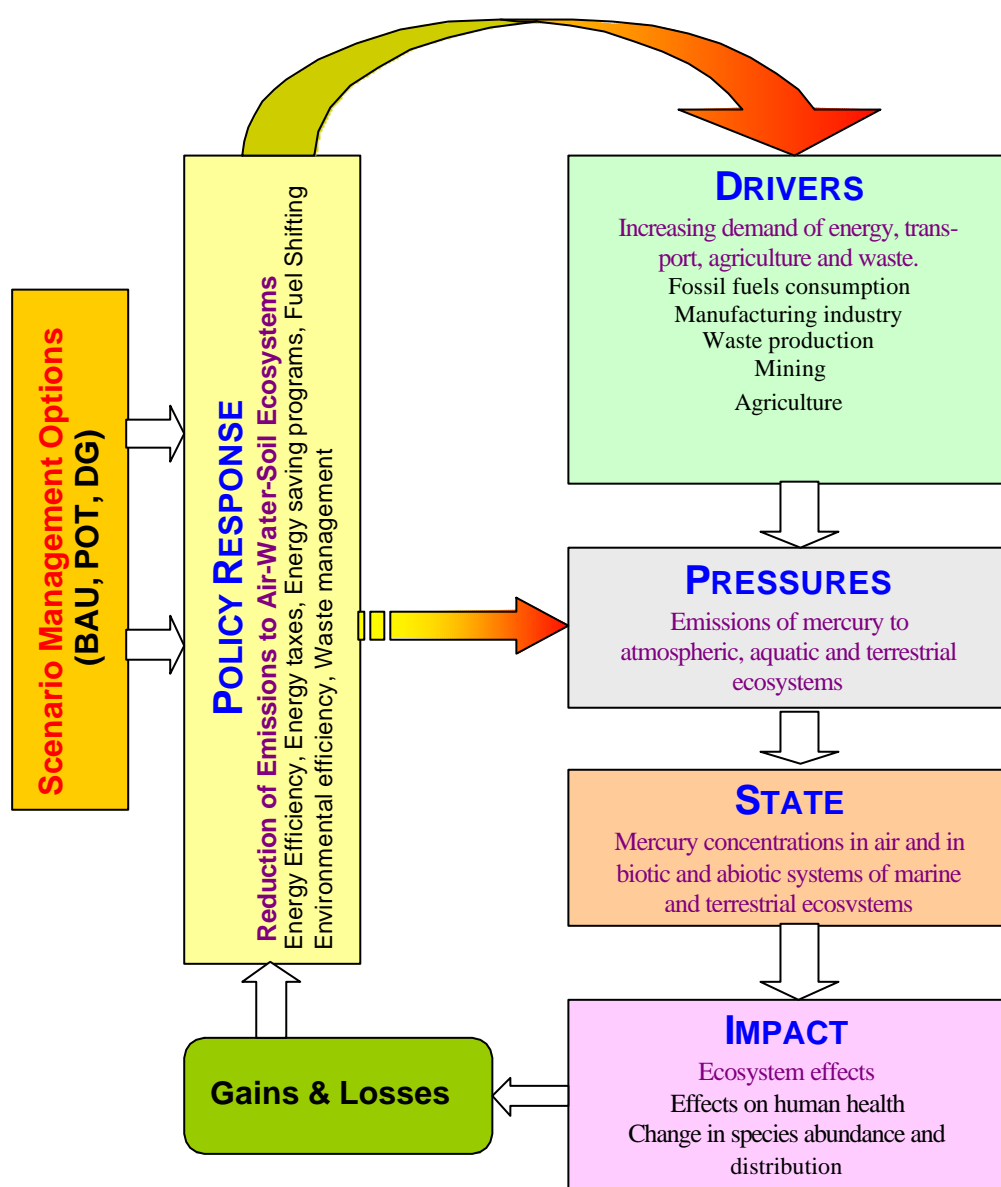


Figure 10.1 Example of a conceptual Driver-Pressure-State-Impact-Response (DPSIR) framework aimed to control and reduce the risk for human health and the environment due to mercury exposure BAU: Business as usual scenario; POT: Policy target scenario; DG: Deep green scenario. Source: MERCYMS Project funded by the European Commission – DG Research. Details can be found at <http://www.iiu-cnr.unical.it/MERCYMS/project.htm>.