EXECUTIVE SUMMARY

The **Position Paper on Mercury** is a Technical Report prepared by a number of experts (see attached list) nominated by Member States as part of the "Working Group on Mercury". It fulfils the requirement of the **Council Directive** on Ambient Air Quality Assessment and Management, better known as the Framework Directive (FD) (Council Directive, 1996) and it is aimed to support the preparation of the Daughter Directives (DD) as reported in *Art*. 2 of the FD. The Position Paper (PP) on mercury is based on *state-of-the-art knowledge* of European sources (natural and anthropogenic) and major processes/mechanisms that influence the cycle of mercury in Europe and in the global environment, and ultimately its impact on human health, following the requirement of an integrated approach to the protection of air, water and soil ecosystems as dictated in *Art*. 7.2 of the FD. As the *state-of-the-knowledge* on different aspects involved in mercury pollution is continuously and rapidly evolving, this PP should be considered as a "snapshot" of our current understanding of temporal and spatial patterns of processes/mechanisms of mercury (and its compounds) in the European environment and its impact on human health and sensitive ecosystems.

The **Position Paper on Mercury** is structured in **seven chapters** that report on natural and anthropogenic emissions of mercury on local and regional scales in Europe (Chapter-2) and provides an overview of Best Available Technology (BAT) that can be used to reduce the emission to the atmosphere (Chapter-7). A detailed presentation of major chemical and physical processes involved in the dynamic of mercury in the atmosphere and modeling techniques currently available in Europe to assess spatial and temporal patterns of ambient concentrations and deposition fluxes are discussed in Chapter-3, whereas monitoring and analytical techniques along with ambient concentration data currently available for gaseous and particulate mercury observed at industrial, urban and rural areas in Europe are presented in Chapter-4. Detailed information on major exposure patterns to elemental mercury and mercury compounds (organic and inorganic) are discussed in Chapter-5, whereas Chapter-6 reports on the risk associated to mercury exposure for major population groups in Europe.

It is well known that mercury is a natural element that cannot be created or destroyed and the same amount has existed on the planet since the earth was formed. A significant amount of research indicate that natural and human (anthropogenic) activities can redistribute this

element in the atmospheric, soil and water ecosystems through a complex combination of different chemical and physical mechanisms. During the industrial times due to its unique physico-chemical properties (i.e., high specific gravity, low electrical resistance, constant volume of expansion), it has been employed in a wide array of applications (i.e., manufacturing, dentistry, metallurgy) and as result of its uses the amount of mercury mobilised and released into the atmosphere has increased compared to the pre-industrial levels. The atmosphere is the major transport (re-distribution) media of mercury in the environment, it is released from a variety of point and diffuse sources, is dispersed and transported in the air, deposited to the earth and stored in or redistributed between water, soil and atmospheric compartments. Wet deposition plays a major role in the transfer of mercury from the atmosphere to surface waters and land. Even after it deposits, mercury is partly emitted back to the atmosphere either as a gas or associated with particles, to be re-deposited elsewhere. It has been extensively demonstrated that mercury accumulates most efficiently in the aquatic food web. Predatory species at the top of the food web generally have higher mercury concentrations. Therefore, mercury cycling and mercury partitioning between different environmental compartments and its impact on human health depend upon the combination of complex phenomena that are related to numerous environmental parameters as described in detail in this PP.

Important findings and remarks highlighted in each chapter of the PP are summarised below, whereas the recommendation of the WG addressed to the Commission are reported in a separate ("Recommendation") chapter of this PP.

1. Studies of occupationally exposed humans have shown slight adverse effects on the CNS and kidneys, and probably also on the thyroid, from inhalation of ***elemental mercury*** (Hg^0) at long-term air levels of 25-30 µg m^{-3}. Starting from this lowest observed adverse effect level (LOAEL), we propose a conversion factor of 10 for the continuous exposure of the general population during a whole lifetime, an uncertainty factor of 5 for the use of a LOAEL (instead of a no observed adverse effect level), and 10 for variability in toxicokinetics and individual susceptibility. The limit value will then be 0.05 µg m^{-3}, as an annual average for the general population (Chapter-6).

2. The developing brain is considered the most sensitive target organ for ***methyl mercury***, which occurs in the human diet. For a risk assessment the US Environmental Protection

Agency (EPA) uses a reference dose (RfD) at which no adverse effects should occur. The Rfd has recently been re-evaluated by the National Research Council. It is now derived from an analysis of data from the Faroe Islands study of children and their mothers exposed to methyl mercury during pregnancy.

3. A **benchmark dose analysis** was performed on cord blood Hg from the Faroe Islands study and neuropsychological tests at seven years of age. The cord blood data were converted to maternal intakes. The EPA chose an uncertainty factor of 10 accounting for inter-individual variability in pharmacokinetics, gaps of knowledge on possible long term effects, and uncertainty concerning the relationships between cord and maternal blood mercury concentration. No new information has emerged that would change the risk assessment. Moreover, the considerations made for the US should be valid also for the European population.

   We therefore consider the **US EPA RfD of 0.1 µg per kg body weight and day** to be appropriate for **Europe**. It should be noted that it is mainly relevant for fertile women. The reference dose will be exceeded if the diet is contaminated with mercury, this mainly applies to fish. As an example, if the weekly intake is about 100 g (one typical fish meal per week) of fish with roughly 0.4 mg kg^{-1}, the RfD will be exceeded. Since one fish meal per week should be possible, an aim of keeping fish Hg levels below this limit seems appropriate. If this is not possible, dietary restrictions with respect to fish with high mercury content should be considered. However, fish also is a source of proteins, selenium, and fatty acids. As a consequence risk management of mercury exposure, e.g. dietary restrictions, should be based on a risk-benefit analysis (Chapter 6).

4. Numerous **animal experiments** have shown interactions between nutrients and methyl mercury, no human data has been provided, but a modifying effect of nutrients e.g. selenium is likely to occur.

5. The proposed **limit value** for Hg^0 of 0.05 µg m^{-3} is rarely exceeded in ambient air in Europe. Exposure to elemental Hg from dental amalgams in most cases represents a daily uptake higher than this level would give rise to (Chapter-5).

6. In **European populations** where fish and other seafood represent a considerable part of the diet, the value of 0.1 µg MeHg kg^{-1}-body weight per day could be considerably

exceeded. Models for the population exposure to MeHg have been developed, but owing to scarcity of input data like dietary surveys and data on fish Hg, a quantification of the extent of exposure to MeHg in Europe is not available (Chapter-5).

7. Since **exposure to methyl mercury** via diet is the critical mercury problem in Europe, the reduction of potential exposure to this Hg species should be the focus for the steps to be taken in Europe (Chapter-1, -5 and -6).

8. The **origin of methylmercury in fish** is to a large extent anthropogenic emissions of mercury to air which is subjected to long-range transport, transformations and deposition to terrestrial and aquatic systems. Mercury is accumulated in forest soils from where it only slowly is transported to aquatic ecosystems. In aquatic ecosystems, a fraction of the mercury deposited directly and transported from surrounding catchments is transformed into methylmercury compounds which are readily taken up and bioaccumulates in aquatic food-chains. *Industrial discharges of mercury directly to water systems will have the same effect.* Accumulation of mercury in forest soils may also lead to adverse effects on soil micro-organisms, which has a potential impact on mineralisation processes (Chapter-1).

9. Due to the complexity of the biogeochemistry involved in transfer and transformation of mercury from the atmospheric deposition to methylmercury in fish, a **universal relationship between mercury input and methylmercury levels in fish does not exist**, but will be dependent on local conditions. However, research performed in Sweden has proven a general link between atmospheric deposition and methylmercury levels in fish, along a south-to-north decreasing deposition gradient. A decrease of fish methylmercury levels following reduction of the atmospheric input has also been observed. Thus, reduction of mercury emissions to the atmosphere is an important measure to reduce methylmercury levels in fish and thus reducing human exposure in Europe (Chapter-1)

10. **Atmospheric mercury** exists mainly in the form of elemental mercury vapour (Hg^0) (90 to 99%), particle bound mercury (< 5%) and gaseous divalent mercury (*e.g.* $HgCl_2$) (<5%). Emissions from anthropogenic sources can occur in all three forms. Atmospheric deposition occurs mainly via dry deposition or wash-out of particle bound and gaseous divalent mercury. Elemental mercury contributes to the deposition via

oxidation in air or in cloud droplets. Mercury in the form of elemental vapour (Hg^0) has a long atmospheric lifetime which makes transport on hemispheric and global scales feasible. In the northern Hemisphere, anthropogenic emissions have increased the background concentrations of mercury in air by a factor of 2-3 since before industrialisation (Chapters-1, -2 and -3).

11. There is a fairly good understanding of major anthropogenic and natural sources and source regions in Europe at present. Various factors affecting the amount of emissions from these sources are also well defined. However, quantitative assessment of the emissions is not always complete and accurate to the extent requested by major users of emission inventories, such as policy makers preparing emission reduction strategies at local, regional, and even global scale, and modellers providing input to these strategies (Chapter-2 and Chapter-3).

Current estimates of **mercury emissions** from anthropogenic sources in Europe indicate that as much as 340 tonnes of this element can be emitted annually, with 33% (~112 tonnes) released in EU-15 member countries, 26% (88 tonnes) in accession candidate countries and 41% (138 tonnes) in other European countries. More than half of these emissions are generated during the combustion of coal in utility, industrial and residential boilers. Another 200 tonnes of mercury annually is emitted to the European atmosphere from natural sources, including the re-emission of mercury emitted previously from the anthropogenic sources and deposited to the aquatic and terrestrial surfaces. The accuracy of emission estimates for anthropogenic sources is within 30% except for waste incineration (it could be as high as a factor of 5). No assessment of the accuracy of natural source emissions has been made so far but it is believed that emission estimates for natural sources are much less accurate than the emission estimates for anthropogenic sources (Chapter-2).

Information on **chemical speciation** of mercury by source category is crucial for modellers simulating the fate, behaviour, and transport of mercury in the environment and policy makers using the information on environmental human health effects of this element. As much as 60% of anthropogenic emissions of mercury in Europe is estimated to be in a gaseous elemental form, 30% as gaseous bivalent mercury and 10% as elemental mercury on particles. A majority of emissions from natural sources is believed to be in a gaseous elemental form. At present, anthropogenic mercury

emissions in Europe are estimated to be nearly 15% of the total mercury that annually is released in the world to the global atmosphere (Chapter-2).

12. A number of different **atmospheric modeling tools** have been developed within European and national research projects and within the UN-ECE framework. In particular integrated mercury modeling systems have been developed and tested for North and Central Europe, and Mediterranean region. The main differences in these modeling tools are related to the type of approach used to model different chemical and physical processes on local and regional scales, spatial and temporal resolution and accuracy of input data. Further development of modelling tools is needed to accurately determine source-receptor relationships for mercury deposition in Europe. At present, lack of monitoring data for atmospheric mercury species is one of the main limiting factors for the evaluation and further refinement of models for policy and environmental (regulatory) planning applications (Chapter-3).

13. **Monitoring** of wet deposition is an efficient measure of overall impact of atmospheric deposition and is useful to follow up time-trends and results of control measures on a regional scale. Wet deposition monitoring of mercury in Scandinavia has shown decreasing levels since the early nineties, which is mainly the results of emission reductions in northern and central Europe. Monitored wet deposition can also be used to assess the overall input to aquatic and terrestrial ecosystems. Monitoring of Hg^0 (or TGM = Total Gaseous Mercury = Hg^0 + small fractions of other gaseous species) may provide important information on the effectiveness of emission control measures adopted at local scales on a short-time basis compared to the regional background contributions. Monitoring of gaseous divalent mercury (or RGM = Reactive Gaseous Mercury, an operational definition) and particle bound mercury (or TPM = Total Particulate Mercury) is necessary for an increased understanding of atmospheric transport and transformation processes as well as for model evaluation and testing (Chapter-4).

14. **There is a lack of standard methods** in Europe for assessing the levels of mercury (and its compounds) in ambient air and precipitation, which does not allow a comparison of mercury concentration data obtained at different sites by different laboratories using different sampling and analytical procedures. For **wet deposition and TGM monitoring**, quite similar methods are currently used by a number of

European laboratories and a standardisation could be achieved with relatively moderate efforts. For **TPM and RGM**, promising methods have been employed in European research projects but further testing and evaluation is needed before a standardisation can be achieved (Chapter-4).

15. A number of **control options** are available for mercury emission reductions. Mercury emissions are also reduced by systems for reducing emissions of other pollutants such as sulphur and fine particles although the efficiency may vary considerable depending on emission source (Chapter-7).