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Lead and Cadmium Working Group
First meeting
Geneva, 18–22 September 2006

Report of the first meeting of the Lead and Cadmium Working Group

I. Introduction

1. At its twenty-third session, in February 2005, the Governing Council of the United Nations Environment Programme (UNEP) adopted decision 23/9 III on lead and cadmium, in which it reaffirmed its decision 22/4 III of 7 February 2003 on lead; requested the Executive Director of UNEP to undertake a review of scientific information, focusing especially on long-range environmental transport, to inform future discussions on the need for global action in relation to lead and cadmium; encouraged Governments and other stakeholders to increase contributions in order to facilitate the timely implementation of the work required by the decision; and requested the Executive Director to report on implementation of the decision as it related to lead and cadmium to the Governing Council at its twenty-fourth session, to be held in February 2007.

2. As part of the implementation of the decision, UNEP established the Lead and Cadmium Working Group to assist it in its work. In a letter of 16 May 2005 and subsequent correspondence, it invited Governments and intergovernmental and non-governmental organizations to submit information relevant to the reviews of scientific information and to nominate members to the Working Group. First drafts of the reviews were circulated to Working Group members in May 2006 for consideration. Following incorporation of the comments received, the revised drafts were circulated in August 2006.

3. The aim of the Working Group at its first meeting was to assist UNEP with the development and possible finalization of the reviews and to prepare a summary of the key findings of each review, indicating whether there was evidence of any significant adverse impacts on health and the environment of global concern arising from the release of lead and cadmium into the environment, for submission to the Governing Council at its twenty-fourth session.

II. Opening of the meeting

4. The first meeting of the Lead and Cadmium Working Group was held at the headquarters of the World Meteorological Organization in Geneva, from 18 to 22 September 2006. The meeting was opened at 10.25 a.m. on Monday, 18 September 2006 by Mr. Maged Younes, Head of the Chemicals Branch of the UNEP Division of Technology, Industry and Economics.

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5. In his opening statement, Mr. Younes welcomed participants, noting with satisfaction the broad regional representation in the Working Group, and he expressed his appreciation to the donors who had provided support to the Working Group, especially the Governments of Norway, Sweden and Switzerland. Noting that decision 23/9 III did not give details with regard to the topics to be covered in the reviews, he said that, as the method followed in developing the 2002 UNEP Global Mercury Assessment report had proved to be successful, UNEP had decided to adopt a similar method to prepare and finalize the reviews of scientific information on lead and cadmium.

6. Outlining the mandate of the Working Group, he drew attention to the difference between Governing Council decision 21/5 on mercury assessment and its decision 23/9 III on lead and cadmium, namely that the latter called only for a scientific review, and not advice on mitigation strategies. He added that the key findings of the Working Group would not only facilitate the discussions of the Governing Council, but would also be useful in a broader context. Recalling that UNEP already had several other mandates relevant to lead and cadmium, he said that one of the priorities for UNEP in 2007 would be to contribute actively to the effective implementation of the recently adopted Strategic Approach to International Chemicals Management (SAICM), in order to achieve the aim expressed in the Plan of Implementation of the World Summit on Sustainable Development to use and produce chemicals by 2020 in ways that led to the minimization of significant adverse effects on human health and the environment.

III. Organization of work

A. Election of officers

7. The Working Group elected Mr. Mohammed Khashashneh (Jordan) and Mr. Mike Roberts (United Kingdom of Great Britain and Northern Ireland) to serve as co-chairs of the meeting.

B. Adoption of the agenda

8. The Working Group adopted the following agenda, on the basis of the provisional agenda set out in document UNEP(DTIE)/Pb&Cd/WG.1/1:

1. Opening of the meeting.
2. Organization of work.
3. Consideration and possible finalization of the draft reviews of scientific information on lead and cadmium.
4. Preparation of technical summaries of the key findings of each review.
5. Other matters.
6. Adoption of the report of the meeting.
7. Closure of the meeting.

C. Organizational matters

9. In considering the sub-item, the Working Group had before it a note by the secretariat outlining the mandate of the Working Group (UNEP(DTIE)/Pb&Cd/WG.1/2). On the basis of that mandate, the Working Group agreed to meet in plenary from 10 a.m. to 1 p.m. and from 3 p.m. to 6 p.m., subject to adjustments as necessary. It also agreed to establish such drafting and other subsidiary groups as it deemed necessary. In addition, it decided that it would apply the rules of procedure of the UNEP Governing Council to its meeting, with the exception of the rules which applied to voting.

D. Attendance

10. The meeting was attended by representatives of the following countries: Argentina, Armenia, Australia, Austria, Bangladesh, Belarus, Benin, Bhutan, Brazil, Bulgaria, Burkina Faso, Burundi, Cameroon, Canada, Chile, China, Costa Rica, Côte d’Ivoire, Croatia, Cuba, Czech Republic, Denmark, Dominican Republic, Ecuador, Ethiopia, Finland, Gambia, Germany, Ghana, Haiti, Honduras, India, Iran (Islamic Republic of), Japan, Jordan, Kenya, Kyrgyzstan, Lebanon, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mongolia, Morocco, Mozambique, Niger, Norway, Pakistan, Paraguay, Philippines, Poland, Qatar, Republic of Moldova, Romania, Russian Federation, Rwanda, Senegal, Spain, Sri Lanka, Sweden, Switzerland, Syrian Arab Republic, Thailand, Togo, Trinidad and Tobago,

United Kingdom of Great Britain and Northern Ireland, United States of America, Yemen and Zimbabwe.

11. The meeting was also attended by representatives of the following United Nations bodies and specialized agencies: Secretariat of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal; Secretariat of the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade; and World Health Organization (WHO).

12. The meeting was also attended by representatives of the following intergovernmental organizations: European Commission and South Asia Cooperative Environment Programme.

13. The meeting was also attended by the following non-governmental organizations: Centre de recherche et d'education pour le développement (CREPD); International Cadmium Association (ICdA); International Fertilizer Association (IFA); International Lead Zinc Research Organization (ILZRO); Mercury Policy Project; and Storm Coalition/Toxics Caucus, Canadian Environmental Network (CEN).

14. A complete list of participants is available as document UNEP(DTIE)/Pb&Cd/WG.1/INF/5.

IV. Consideration and possible finalization of the draft reviews of scientific information on lead and cadmium

15. In considering the item, the Working Group had before it document UNEP(DTIE)/Pb&Cd/WG.1/3, which summarized the process followed in preparing and considering the first drafts of the reviews of scientific information on lead and cadmium and described how the Working Group might proceed in its consideration of the two texts. It also had before it copies of the reviews, as described in document UNEP(DTIE)/Pb&Cd/WG.1/4.

16. In a general discussion on the item, the Working Group agreed that the reviews provided a good starting point for its work. It also agreed that, in view of the limited time available and the specific mandate of the Working Group, its discussions should focus primarily on the scientific aspects of the reviews and that priority should therefore be given to the consideration of the chapters of each review relating to: long-range transport in the environment (chapter 7); sources and releases to the environment (chapter 5); impacts on the environment (chapter 4); and human exposure and health effects (chapter 3), in that order. In addition, it was agreed that consideration would be given to the chapters of each review relating to chemistry (chapter 2) and production, use and trade patterns (chapter 6), as those chapters placed in context the environmental effects of lead and cadmium. Chapter 8, on prevention and control technologies and practices, chapter 9, on initiatives for preventing or controlling releases and limiting exposures, and the appendices, which provided an overview of existing and future national actions relevant to lead and cadmium, would not be discussed, as the information that they contained fell outside the mandate of the Working Group.

17. It was noted that, while it might be difficult to finalize the reviews at the current meeting, given the limited time available, the Working Group should endeavour to provide as comprehensive a basis as possible for the UNEP report to the Governing Council, in particular with regard to key findings. It was also noted that, as there had been a limited budget available for their preparation, the reviews were not exhaustive.

18. Noting with concern that some of the information presented in the reviews had been derived from outdated sources or had not been endorsed by an official body, the Working Group agreed that, to the extent possible, the information presented in the reviews should be recent, scientific and peer reviewed. In the absence of such information, the reviews should draw on other up-to-date information which was likely to be endorsed by an official body in the near future, with a clear indication of the source of the information and its status. Acknowledging the need to proceed with particular caution with regard to chapter 3 of each of the reviews, which dealt with human exposure and health effects, the Working Group agreed that all the information presented in that chapter should be reviewed by WHO.

19. In addition, the Working Group noted the need to identify information gaps and to determine whether or not information was available to fill those gaps. It was observed that most of the data currently available came from developed countries. The Working Group also discussed the need to include in the reviews information arising from social and economic studies, concluding that, in line with decision 23/9 III and the Working Group's mandate, such information might be considered as a next step upon completion of the reviews, when discussions on risk management were taken up. One

expert suggested that information should be presented in the reviews in a manner which allowed its relevance to a particular country to be easily identified.

20. Following the general discussion, the Working Group considered and proposed amendments to individual chapters of the revised draft reviews. During that consideration, the Working Group requested the secretariat to include in the introductory chapter of the revised draft reviews a description of the process followed in preparing the reviews and of the different status accorded to the various chapters, and to prepare a paragraph outlining the content of each chapter and indicating how it related to the mandate given to UNEP in decision 23/9 III.

21. During the discussion, many experts expressed concern about the challenges faced by developing countries in terms of the use, management and disposal of new and used products containing lead and cadmium, including batteries and electronic equipment, as those countries often lacked the necessary infrastructure to ensure the environmentally sound management of such wastes. Concern was also expressed about the export to developing countries of products whose normal use could cause exposure to lead and cadmium. Although several experts underscored the desirability of reflecting those issues in the reviews, on the basis of additional information which was presented to the Working Group, it was agreed following some debate that the information had been submitted at too late a stage of the meeting to be incorporated into the reviews but, given its significance, would nevertheless be made available to the Governing Council, together with any other new information provided subsequent to the meeting, as an information document.

22. It was agreed that the secretariat would prepare updated versions of the revised draft reviews, taking into account the comments made during the meeting, which would be provided to the Governing Council at its twenty-fourth session as background information in English only. Those versions would be considered interim and subject to further amendments in the future as new information became available. It was also agreed that chapter 3 of each of the revised draft reviews, relating to human exposure and health effects, would require further attention by WHO and would be finalized by WHO and UNEP within 10 days of the meeting. Regrettably, it would not be possible for all the experts at the meeting to comment on the text.

23. The texts of the updated versions of the revised draft reviews were made available to experts at the meeting and are also available on the Lead and Cadmium Activities website at http://www.chemical.unep.ch/Pb_Cd/WG-meeting.htm.

V. Preparation of technical summaries of the key findings of each review

24. In its consideration of the item, the Working Group reviewed document UNEP(DTIE)/Pb&Cd/WG.1/5 and agreed to take into account the issues outlined in that document when developing its summaries of the key findings. The Working Group also agreed to base its work on draft summaries of key findings on lead and cadmium which had been submitted by the United States of America.

25. During the discussions, several experts proposed key findings based on the additional information presented to the Working Group during the meeting and which would not be included in the interim versions of the reviews. Other experts said that, while they did not contest the importance of the issues, the key findings should be based solely on the information presented in the reviews.

26. Following a discussion, the Working Group amended and agreed on the texts of the key findings for lead and cadmium, pending some clarifications to be provided subsequent to the meeting. The Working Group further agreed to entrust the secretariat with the preparation of the final texts, which would be submitted to the Governing Council at its twenty-fourth session. The texts, as agreed by the Working Group and amended by the secretariat on the basis of the discussions in plenary, are set out in the annexes to the present report.

27. The Working Group agreed that, notwithstanding the limited time available at the meeting, the issues raised in document UNEP(DTIE)/Pb&Cd/WG.1/5 had been adequately addressed in the key findings.

VI. Other matters

28. No other matters were raised at the meeting.

VII. Adoption of the report of the meeting

29. The Lead and Cadmium Working Group adopted its report on the basis of the draft report which had been circulated during the meeting, as amended, and on the understanding that the finalization of the report would be entrusted to the secretariat.

VIII. Closure of the meeting

30. Following the customary exchange of courtesies, the Co-Chair declared the meeting closed at 6.15 p.m. on Friday, 22 September 2006.

Annex I

Key scientific findings for lead

I. Hazardous properties, exposures and effects

1. Lead is a heavy metal that is toxic at very low exposure levels and has acute and chronic effects on human health. It is a multi-organ system toxicant that can cause neurological, cardiovascular, renal, gastrointestinal, haematological and reproductive effects. The type and severity of effects depend on the level, duration and timing of exposure. Lead is accumulated in bone and may serve as a source of exposure later in life. Organo-lead compounds, such as tri-alkyl-lead and tetra-alkyl-lead compounds, are more toxic than inorganic forms of lead.

2. In the environment, lead is toxic to plants, animals and micro-organisms. It bioaccumulates in most organisms. In surface waters, residence times of biological particles containing lead have been estimated at up to two years. Although lead is not very mobile in soil, lead may enter surface waters as a result of the erosion of lead-containing soil particles and the dumping of waste containing lead products.

II. Environmental transport: extent to which lead is transported on intercontinental, regional, national and local scales

3. Lead is released by various natural and anthropogenic sources to the atmosphere and to aquatic and terrestrial environments and there are fluxes between these compartments. Lead released into the atmosphere is deposited on land and into aquatic environments and some lead released onto soil over time is also washed out to aquatic environments.

4. Once emitted to air, lead is subject to atmospheric transport. It is mainly emitted to the atmosphere in particle form. The atmospheric transport of lead is governed by aerosol (particle) transport mechanisms: in the atmosphere, lead may be transported on local, national, regional or intercontinental scales, depending on various factors, including particle size, the height of the emission outlet and meteorology. Because it has a relatively short residence time in the atmosphere (days or weeks), this metal is mainly transported over local, national or regional distances. For example, based on modelling results, the annual contribution of external emission sources to the total lead deposition in Europe has been estimated not to exceed 5 per cent, and in North America may be even lower. Episodically, however, the contribution of intercontinental transport may be significantly higher at certain locations in these two continents on some days of the year, although annual lead contribution from intercontinental transport is low.

5. While the model used to produce these results is state-of-the-art, it should be noted that the data underlying the model are based mainly on emission estimates from 1990. Another model calculation published in 1997 estimated that 5–10 per cent of emissions in the Euro-Asiatic region in the winter are deposited in the northern Arctic. It should be noted that model results have uncertainties and the resulting figures should therefore be interpreted with caution.

6. The regional and intercontinental atmospheric transport of lead contributes to deposition in remote regions such as the Arctic, where there are few local sources for lead releases. Some evidence of the limited intercontinental transport of lead is obtained from measurements of stable isotope signatures of the airborne dust in combination with air-mass back trajectories. These measurements indicate the origin of dust particles transported by air masses, and thereby provide evidence that aerosols carrying lead are transported intercontinentally and from industrialized regions to remote regions such as the Arctic, where there are very few local emission sources. Soil in Kauai, Hawaii, was found to contain lead from diverse distant sources, including lead from anthropogenic sources in Asia and North America. Another study, in Japan, shows long-range transport of air pollution (including lead) from continental Asia.

7. Europe and the Asian part of the Russian Federation contribute all but a small percentage of the airborne lead reaching the Arctic. Models show that the main atmospheric pathways lie across the north Atlantic, from Europe and from Siberia. Between 95 and 99 per cent of the lead deposition in the Arctic is anthropogenic. Furthermore, over the period 1993–1998, snow samples in the part of the Arctic north of Russia showed a concentration gradient with levels increasing from the easternmost to

the westernmost monitoring sites. This was the consequence of the different times at which leaded petrol was phased out in different regions and of varying trends in industrial development. The transport of lead follows seasonal patterns. Lead levels in airborne particles are lowest in early autumn, and at that time of year lead reaching the Canadian Arctic comes mostly from natural sources in the Canadian Arctic archipelago and western Greenland. In late autumn and in winter, airborne lead comes primarily from industrial sources in Europe. The measured snow concentrations, however, are low compared with deposition in industrialized areas.

8. The largest single ice-core based dataset used to reconstruct Arctic metal deposition comes from the Greenland Summit deep drilling programme. The data show that the lead levels increased significantly following the industrial revolution in the nineteenth century. Lead deposition in the 1960s and 1990s was eight times higher than in pre-industrial times. With the phase-out of leaded petrol since 1970 and the implementation of emission controls, lead concentration in the ice-core has sharply decreased. The results of the programme indicate that anthropogenic emissions – and, in particular, releases of lead through the use of leaded petrol – during a given period constituted a more important source than natural sources of lead deposited in Greenland. The remarkable reduction, in parallel with the removal of lead in petrol in 1970–1997, has resulted in a return to pre-industrial levels of lead in the ice-core data.

9. With regard to aquatic systems, rivers are transport media for lead on a national and regional scale. The oceans are also a transport medium. The oceanic residence time of lead ranges from about 100 to 1,000 years, which may indicate a potential for ocean transport. Concentrations of scavenge-type trace metals, however, typically decrease with distance from the sources and, in general, concentrations of scavenge-type metals such as lead generally tend to decrease along flow paths of deep water because of continual particle scavenging and subsequent sedimentation.

10. The contribution of lead to the marine environment from Belgium, Denmark, France, Germany, the Netherlands, Norway, Sweden and the United Kingdom via rivers is currently larger than the airborne inputs.

III. Sources of releases

11. Important releases of lead may be grouped into the following categories: releases from natural sources, in other words, releases resulting from the natural mobilization of naturally occurring lead from the Earth's crust and mantle, such as volcanic activity and the weathering of rocks; current anthropogenic releases from the mobilization of lead impurities in raw materials such as fossil fuels and other extracted and treated metals; current anthropogenic releases of lead used in products and processes as a result of mining and processing activities, manufacturing, use, disposal, recycling and reclamation; releases from incineration and installations for municipal waste, open burning and from residues containing lead; and the mobilization of historical lead releases previously deposited in soils, sediments and wastes. Emissions from leaded petrol, metal processing including recycling, mining activity and probably oceans can be considered as the sources of relevance for the long-range transport of lead.

A. Atmospheric releases (emissions)

12. The most recent study of total anthropogenic atmospheric emissions estimated the total emissions in the mid-1990s at 120,000 tonnes, of which 89,000 tonnes originated from the use of petrol additives. Besides fuel additives, non-ferrous metal production and coal combustion were the major sources. The major natural sources of emissions to air are volcanoes, airborne soil particles, sea spray, biogenic material and forest fires.

13. Very different estimates on total emissions by natural processes have been reported. A study from 1989 estimates the total emission in 1983 at between 970 and 23,000 tonnes per year, whereas a new study estimates the total emissions from natural sources at between 220,000 and 4.9 million tonnes per year. The large disparity is mainly due to different estimates on the amount of lead moved around with soil particles.

14. As of June 2006, only two countries worldwide exclusively used leaded petrol, while 26 countries used both leaded and unleaded petrol. Since sub-Saharan Africa completely eliminated the import and production of leaded petrol in January 2006, the majority of countries still using leaded petrol are in the Asia-Pacific region. The global consumption of lead for manufacturing of petrol additives decreased from 31,500 tonnes in 1998 to 14,400 tonnes in 2003. In 1970, when the use of

leaded petrol was peaking, about 310,000 tonnes was used for petrol additives in member countries of the Organization for Economic Cooperation and Development (OECD).

15. The total emission and distribution by sources vary considerably among countries. From 1983 to the mid-1990s, the quantified global anthropogenic emission of lead decreased from about 330,000 tonnes to 120,000 tonnes. Emissions have been decreasing in virtually all industrialized countries over the past twenty years. For example, in Europe, from 1990 to 2003, lead emissions decreased by about 92 per cent. In the United States of America, emissions decreased sharply during the 1980s and early 1990s due to the phase out of lead in petrol and reductions from industrial sources. Lead emissions continued to decline, but to a lesser extent, in the period from the mid-1990s to 2002. Overall emissions of lead decreased by about 95 per cent over the 21-year period from 1982 to 2002, falling from about 54,500 tonnes per year in 1982 to about 1,550 tonnes in 2002.

16. The significant reduction of lead emissions was mainly due to restrictions and bans on the use of leaded petrol for vehicles, but also implementation of improved air pollution controls. As an example, in eight European countries, the reported emissions from ferrous and non-ferrous production were, on average, reduced by about 50 per cent over the period 1990–2003, while emissions from waste incineration and from public electricity and heat production, on average, dropped by 98 per cent and 81 per cent respectively. Data on lead emissions and emission trends in developing countries were not available at the time of the preparation of the present document.

17. The open burning in some developing countries of waste products containing lead could be an important source of local and regional lead emissions to the atmosphere.

B. Releases to land and aquatic systems

18. Some lead-containing products are disposed of in various waste deposits or released to soil or the aquatic environment. The major categories are: waste and loss of ammunition from hunting, disposal of products, mine tailings and smelter slag and waste. Other products and wastes, in no particular order, that may contribute to releases during their life-cycle, include paints with lead, lead balancing weights for vehicles, lead sheathing of cables left in the ground and lead batteries (loss by breakage and recycling), and mine tailings and other wastes. The handling of wastes may lead to elevated local and regional release levels in developing countries.

19. Direct industrial and municipal releases to aquatic environments in developed countries are considered small when compared to releases to the atmosphere and land. The major industrial sources are mining and non-ferrous metal production. Weathering of rocks releases natural lead to soils and aquatic systems, which plays a significant role in the global cycle. This release is enhanced by acidic emissions. The open burning in some developing countries of waste products containing lead could be an important source of local and regional lead releases to land and aquatic systems.

IV. Production and uses of lead

20. Lead is mined in more than 40 countries, the major producers being China and Australia, which represent about 30 per cent and 22 per cent of global mining production respectively. Lead-rich minerals most often occur together with other metals, and about two thirds of worldwide lead output is obtained from mixed lead-zinc ores.

21. The total global production of lead from mining has decreased slightly, from 3.6 million tonnes in 1975 to 3.1 million tonnes in 2004. Over the same period, global refined lead production and metal consumption have increased from about 4.7 million tonnes to about 7.1 million tonnes. The reason for the difference between mine production and lead consumption is due to the fact that recycled lead accounts for an increasingly large part of the supply: recycled lead accounted for 45 per cent of global supply in 2003.

22. Lead is used and traded globally as a metal in various products. The major use of lead in recent years is lead batteries, accounting for 78 per cent of reported global consumption in 2003. Other major application areas are lead compounds (8 per cent of the total), lead sheets (5 per cent), ammunition (2 per cent), alloys (2 per cent), cable sheathing (1.2 per cent), and petrol additives (less than 1 per cent). The most significant change in the overall use pattern over the period 1970–2003 is that batteries account for an increasing part of the total, whereas the share of cable sheathing and petrol additives has decreased. Lead as pigment in paints has been discontinued in developed countries but is still used in some developing countries, specifically in industrial settings.

V. Lead issues in developing countries

23. As awareness of the adverse impacts of lead has increased, many uses have been reduced significantly in industrialized countries. In addition, as public awareness has grown, waste management systems have increasingly been put in place in industrialized countries to reduce releases of lead to the environment. That said, however, some of the uses of lead which have been phased out in industrialized countries have continued in developing countries. In addition, use of lead has continued or increased in some less developed regions or countries, for example, in plastics or in paints. Regulations and restrictions are less comprehensive or less well enforced in some developing regions. This has resulted in some of the health and environmental risks, local and regional, that accompany the use, management (including collection, storage, recycling and treatment) and disposal of products containing lead. These hazardous disposal practices include open burning and indiscriminate dumping in sensitive ecosystems such as rivers and wetlands.

24. Another issue faced by developing countries is the export of new and used products containing lead, including electronic equipment and batteries, to those countries which lack the capacity to manage and dispose of the lead in these products in an environmentally sound manner at the end of their life. Another problem is posed by products containing lead that may cause exposure through normal use, such as certain toys.

VI. Levels and time trends in air and deposition

25. Most identified monitoring data for atmospheric lead concentrations and deposition come from Europe and the United States of America, although results from Antarctica, Canada, Japan and New Zealand are also available. Available data generally show a decreasing trend in air concentrations and deposition since about 1990, or earlier, depending on the country and region. For example, in 1990 the concentrations of lead in air were measured at stations located in the central part of Europe and along the coast of the North Sea. Measured background concentrations lay mainly within the 10–30 ng/m3 range. In 2003 the concentrations mainly ranged between 5 and 15 ng/m3. Concentrations in precipitation in central Europe in 1990 were around 2–5 µg /l. In 2003, these concentrations typically ranged from 1 to 3 µg/l.

26. Lead concentration measurements in air in the Canadian Arctic in the period 1980–2000 show a decline in lead concentrations of about 30–50 per cent, whereas data from the Eurasian side (Norway) do not reveal any noticeable trends during the same period.

27. Some modelling has been performed, mostly in Europe, to estimate deposition rates. When reported emissions are used in the models, they generally underestimate deposition (compared to measured data). The underestimation is believed to be due to the failure to include natural emissions and re-emissions of historical releases in models and to uncertainties in reported emissions.

28. In order to estimate long-term trends for different parts of Europe, measurement data were averaged over different countries. The long-term changes of air concentrations and concentrations in precipitation vary considerably across Europe. In central and north-western Europe, concentrations decreased by about 50–65 per cent between 1990 and 2003 based on these data. In northern Europe, concentrations in precipitation decreased by 30–65 per cent. Trend data for ambient lead concentrations in the United States of America for the period 1982–2001 show that, while urban and suburban sites had the greatest decrease in ambient lead concentrations during that period, rural sites also experienced significant reductions. Overall, lead air concentrations across the country have decreased by more than 94 per cent since 1983, based on available data. Furthermore, this trend has continued, although at a reduced rate throughout the 1990s, with lead concentrations decreasing by 57 per cent between 1993 and 2002. Available data indicate that atmospheric deposition is still causing the content of lead in topsoils in Europe to increase in some locations. As there were no data from some developing countries, trends of lead levels in air could not be determined.

29. The decline in use of leaded petrol is reflected in the 85 per cent decline in lead deposition rates in the Arctic from the 1970s to the early 1990s.

30. The main factors affecting the range and deposition of lead emissions include: characteristics of emission sources (higher outlets and higher emission temperatures result in higher emission plumes and, therefore, longer transport ranges); physical and chemical forms of lead in the atmosphere: large particles deposit within short ranges, small particles may be transported further; and meteorology (precipitation and wind speed), terrain, atmospheric stability and other factors.

VII. Human exposure pathways and effects

31. Neurodevelopmental effects in children, even at low levels of exposure, represent the most critical effect. Other adverse effects include neurological, cardiovascular, renal, gastrointestinal, haematological and reproductive effects.

32. Exposure to lead occurs mainly through inhalation of dust and air and ingestion of foodstuffs, water and dust. Attention is drawn to the following:

- Inhalation is an important route of exposure for people in the vicinity of point sources, including open burning of wastes containing lead products, in countries that still use lead in petrol, and in some occupational settings including secondary lead recovery
- Ingestion of lead in dust and soil is a major exposure pathway in children, because of their biological and behavioural characteristics
- Intake of food and beverages is usually the primary source of exposure for adults in the general population

33. There are multiple sources of exposure. Attention is drawn to the following:

- A wide range of exposure sources exist, whose characteristics vary both within and between countries
- In some countries, lead in petrol is still an important source of exposure. Other sources include lead in paint, low temperature-fired ceramics, informal sector recycling of car batteries, mine tailings and the air, soil and dust in the vicinity of point sources (e.g., smelters)
- Dust in homes with paint containing lead pigment can cause elevated blood lead levels in children
- Tap water from leaded pipes can also be an important exposure source
- Other potential sources of exposure include products containing lead, such as cosmetics, traditional medicines, toys and trinkets, contaminated spices and food colouring

34. Certain population groups are vulnerable and especially susceptible to lead. Attention is drawn to the following:

- New data highlight the special vulnerability of small children. Exposure of children can be magnified by their activities and behavioural patterns and biological characteristics
- Exposure starts in utero since lead passes through the placenta into the foetus; thus pregnant women are a population of concern
- Occupational exposure (e.g., some workers in the informal recycling sector)
- Other vulnerable population groups include socially and economically disadvantaged populations and the malnourished, whose diets are deficient in proteins and calcium

35. Lead is a well-documented neurotoxicant. Attention is drawn to the following:

- Lead exposure in children is linked to a lowering of their IQ
- Epidemiological studies consistently find adverse effects in children at blood lead levels down to 10 µg/dl. Recent studies reported lead-induced IQ-decrements in children with blood lead levels below 10 µg/dl
- There is presently no known threshold for the effect of lead
- A growing number of studies suggest that exposure to lead may cause behavioural deficits and lower functional skills during childhood and later in life

36. Attention is drawn to the following observations relating to exposure levels, trends and geographic scope:

- Lead exposures occur in most, or all, countries of the world. Available data suggest that, on the global scale, the highest blood lead levels occur in Latin America, the Middle East, Asia, parts of Eastern Europe and the Commonwealth of Independent States
- Available data indicate a substantial falling trend in environmental lead exposure in many developed countries mainly due to the elimination of lead from petrol, but also to reductions in other sources of exposure (e.g., lead in paint, lead in drinking water and lead in soldered cans). Thus, in the United States of America in the 1970s, over 80 per cent of children had blood lead levels (Pb-B) exceeding 10 µg/dl, but, in a 1999–2002 study, fewer than 2 per cent exceeded this level
- Exposure levels remain elevated in many locations, however, including in some developed countries

37. Lead remains an environmental health problem. Attention is drawn to the following:

- A growing number of countries (mainly developing countries and countries with economies in transition) are recognizing and reporting the problem of environmental lead exposure in some population groups
- In many parts of the world, for many decades, there was very little public awareness of and policies relating to the potential for lead contamination and its public health effects
- As a result of its health effects and impact on development, lead may cause significant economic losses for society

VIII. Impacts on the ecosystem

38. Environmental exposure to lead is greatest near point sources (e.g., smelters), or from lead shot and sinkers used for shooting and fishing. In locations not affected by local sources, there are generally no observed effects on terrestrial organisms and plants and, in the aquatic environment, lead concentrations are normally below known effect levels. One possible important exposure route which has not been included in the review owing to lack of data is the indiscriminate disposal of waste containing lead products in sensitive ecosystems such as the many rivers and wetlands in developing countries.

39. The environmental effects of lead are well documented. Secondary poisoning has also been extensively documented, especially for predators feeding on contaminated animals. There are many reports on the levels of lead in wild mammals, but few reports of toxic effects of the metal in wild or in non-laboratory species. In all species of experimental animals studied, however, lead has been shown to cause adverse effects in several organs and organ systems, including the blood system, central nervous system, the kidney and the reproductive and immune systems.

40. In a significant percentage of European soils, the lead concentrations estimated for areas away from point sources exceed the threshold concentration for adverse effects in soil, and therefore the terrestrial ecosystems are considered to be at risk.

IX. Data gaps

41. A number of data gaps and needs have been identified. Attention is drawn to the following:

- The need to develop and improve exposure assessments and use and release inventories, especially for developing countries
- The need for modelling for the southern hemisphere and a better understanding of ocean transport, re-emissions, and natural releases
- The need to examine the role of long-range transport, the contribution of anthropogenic sources versus natural sources and the influence of local, regional and global sources

- The general lack of data from developing countries where environmental and health problems related to production, trade, use and disposal of lead may be more common and have a different nature that in other regions
- The need to monitor and assess lead levels in various media (such as soil and sediment) and data associated with impacts on humans, ecosystems and animals, including impacts from cumulative exposures to different forms of lead, as well as further emission data that help overcome the uncertainties in the results of the current models
- The need to collect data regarding accidental spills from mine tailings on a global scale and the real extent of these events, especially in developing countries, where capacity building is needed
- The need for real information about the quantities of lead disposed of in the environment, especially in developing countries, where the open burning of lead-containing products is a common practice, which results in atmospheric emissions
- The need to improve the information on the level of contamination of drinking water by lead as a result of leaching from landfills, especially in developing countries
- The need to collect data on concentration levels in large migrating marine mammals
- The need to examine the global flow of lead in products

Annex II

Key scientific findings for cadmium

I. Hazardous properties, exposure and effects

1. Cadmium is a non-essential and toxic element for humans mainly affecting kidneys and the skeleton. It is also a carcinogen by inhalation. Cadmium is accumulated in bone and may serve as a source of exposure later in life.

2. In the environment, cadmium is toxic to plants, animals and micro-organisms. Being an element, cadmium is persistent – it cannot be broken down into less toxic substances in the environment. The degree of bioavailability and potential for effects varies depending on the form of cadmium. Cadmium bioaccumulates mainly in the kidneys and liver of vertebrates and in aquatic invertebrates and algae.

II. Environmental transport: extent to which cadmium is transported on intercontinental, regional, national and local scales

3. Cadmium is released by various natural and anthropogenic sources to the atmosphere, aquatic environments (fresh and salt water environments) and terrestrial environments. There are fluxes between these compartments. Cadmium released to the atmosphere can deposit to land and aquatic environments, and some cadmium released to soil over time will be washed out to the aquatic environments. The long-term sinks are deep-sea sediments and, to a certain extent, controlled landfills, in cases where, owing to its physico-chemical properties, cadmium is immobilized and remains undisturbed by anthropogenic or natural activity (climatic and geological).

4. Cadmium, once emitted to air, is subject to atmospheric transport. It is mainly emitted to the atmosphere in particle form. The atmospheric transport of cadmium is governed by aerosol (particle) transport mechanisms: in the atmosphere, cadmium may be transported on local, national, regional or intercontinental scales, depending on various factors, including, for both natural and anthropogenic sources, particle size, the height of emission outlets and meteorology. Because it has a relatively short residence time in the atmosphere (days or weeks), however, this metal is mainly transported over local, national or regional distances.

5. Based on the relatively scarce specific evidence available, cadmium is considered to be subject to a certain degree of long-range air transport on an intercontinental scale. Intercontinental transport is, however, expected to make only a minor contribution to cadmium levels in regions affected by other, local emitting sources. The regional and intercontinental atmospheric transport of cadmium contributes to deposition in remote regions, such as the Arctic, where there are few local sources for cadmium releases.

6. There is no hemispheric transport modelling for cadmium. As cadmium transport is governed by aerosol transport mechanisms similar to those governing the transport of lead (both are transported on aerosol particles with similar properties), the transport of lead might be used as a rough surrogate of the potential intercontinental transport of cadmium. Lead modelling is described in the UNEP review of scientific information on lead. Taking into account the general similarities between the long-range atmospheric transport of cadmium and lead and building on observations for lead, major contributions to Arctic cadmium pollution can be expected, as is the case with lead pollution, to come from sources located in Europe and in Siberia.

7. With regard to aquatic systems, rivers transport cadmium and other heavy metals on a national and regional scale. Ocean transport also occurs. The oceanic residence time of cadmium has been estimated at about 15,000 years. This indicates that cadmium may be accumulated and transported in significant amounts over long distances in the ocean. It should be noted, however, that oceans have large natural reservoirs of cadmium. The contribution of cadmium via rivers into the marine environment of the North Sea is in the same order of magnitude as the atmospheric deposition, which is the other main pathway of cadmium inputs in the region.

III. Sources of releases

8. Important releases of cadmium may be grouped in the following categories: releases from natural sources, in other words, releases resulting from natural mobilization of naturally occurring cadmium from the Earth's crust and mantle, such as volcanic activity and weathering of rocks; current anthropogenic releases from the mobilization of cadmium impurities in raw materials such as phosphate minerals, fossil fuels and other extracted, treated and recycled metals - particularly zinc and copper; current anthropogenic releases of cadmium used in products and processes, as a result of use, disposal, recycling, reclamation, open burning or incineration; releases from municipal installations; and the mobilization of historical anthropogenic and natural cadmium releases previously deposited in soils, sediments, landfills and waste or tailings piles.

A. Atmospheric releases (emissions)

9. The most recent study of global anthropogenic emissions estimated the total in the mid-1990s at 2,983 tonnes. Newer estimates are not available. Available data indicate, however, that anthropogenic emissions of cadmium have decreased by an average of about 50 per cent from 1990 to 2003 in developed countries. Adequate data are not available to evaluate trends in developing countries. The main sources of emissions are non-ferrous metal production and fossil fuel combustion. Other sources include iron and steel production, waste incineration and cement production. In some developing countries, open burning of cadmium-containing products and indiscriminate dumping contribute to local and regional exposure.

10. The major natural sources for emission to air are volcanoes, airborne soil particles, sea spray, biogenic material and forest fires. Very different estimates of total releases of cadmium to the atmosphere by natural processes have been reported. A study from 1989 estimates the total emissions in 1983 at between 150 and 2,600 tonnes per year, whereas a new study estimates the total emissions from natural sources at between 15,000 and 88,000 tonnes per year. The large discrepancy is mainly due to different estimates of the amount of cadmium released to air with soil particles. Because of the limited data and huge differences between the findings of these two studies, there is uncertainty about the relative magnitude of natural emissions as compared to anthropogenic emissions. The more recent study suggests that natural emissions might be between 5 and 30 times higher than anthropogenic emissions.

11. Various human activities (such as mining, metal production, combustion of fossil fuels and other industrial processes) have resulted, however, in elevated cadmium concentrations in the environment. For example, cadmium deposition in the 1960s and 1970s in the Greenland ice core was eight times higher than in pre-industrial times. These data suggest that industrial emissions have been more important as a source of deposition in Greenland – and perhaps other Arctic areas – than natural emissions. Recent data indicate that cadmium deposition levels have steady declined since the 1970s.

12. The open burning in some developing countries of waste products containing cadmium could be an important source of local and regional cadmium emissions to the atmosphere.

B. Releases to land and aquatic systems

13. Some cadmium-containing products are disposed of in various waste deposits, released to soil or the aquatic environment. Major categories of these releases include residues from coal combustion, mine tailings, and smelter slag and waste. In recent years, nickel-cadmium (NiCd) batteries and primary batteries with cadmium content have constituted a major source of cadmium disposed of in landfills with municipal waste. The long-term fate of the cadmium accumulating in the landfills is uncertain and may represent a future source of releases. The handling of wastes may lead to elevated local and regional release levels for developing countries.

14. Atmospheric deposition, phosphate fertilizers and sewage sludge appear to be the major contributors to cadmium levels in agricultural soils. In a number of European countries, atmospheric deposition, animal manures, sewage sludge and the presence of cadmium in fertilizers are causing the content of cadmium in topsoil to increase. Atmospheric deposition has been decreasing, but in the late 1990s it was still a major source of cadmium input to agricultural soils. As cadmium is taken up by plants, increased soil concentrations can result in increased concentrations in food products.

15. The weathering of rocks releases cadmium to soils and aquatic systems and plays a significant role in the global cadmium cycle. This release is enhanced by acidic emissions. Weathering and erosion result in the transport by rivers of large quantities of cadmium to the world's oceans. An annual gross input of 15,000 tonnes of cadmium has been estimated. Moreover, between about 900 and 3,600 tonnes

of cadmium are estimated to be deposited to aquatic environments throughout the world through atmospheric deposition of emissions originating from anthropogenic and natural sources.

16. The open burning in some developing countries of waste products containing cadmium could be an important source of local and regional cadmium releases to land and aquatic systems.

IV. Production and uses of cadmium

17. Cadmium is produced mainly as a by-product of mining, smelting and refining of zinc and, to a lesser degree, as a by-product of lead and copper production. It is therefore primarily a function of zinc production rather than cadmium demand. Global cadmium production almost doubled between 1950 and 1990. Since 1990, global consumption has remained constant, at about 20,000 tonnes per year, although major changes have occurred with the geographical distribution of this production. Until 1997, production in Europe, the Americas and Asia remained constant. Since 1997, however, production in Asia has increased sharply, whereas the production in Europe has decreased. Major shifts in smelting and refining technology by many of the world’s zinc refiners from pyrometallurgical to hydrometallurgical processes (50 per cent in 1958 to 81 per cent of capacity in 2003) have led to significant decreases in releases of cadmium to the environment.

18. Recycled cadmium accounts for about 18 per cent of total global supply. Countries with significant collection and recycling activities include France, Germany, Japan, the Republic of Korea, Sweden and the United States of America.

19. Cadmium is used and traded globally as a metal and as a component in various products. A growing proportion of refined cadmium consumption is accounted for by NiCd batteries, which in 2004 represented 81 per cent of the total. Other major uses of refined cadmium are: pigments for plastics, ceramics and enamels; stabilizers for plastics; plating on iron and steel; and as an alloying element of some lead, copper and tin alloys. Since 1990, consumption for pigments, stabilizers, alloys and other uses has decreased significantly.

20. Products containing cadmium are not typically collected separately from the general waste stream in developing countries. Therefore cadmium discards will end up in municipal waste and disposed of in landfills, incineration, open burning or indiscriminate dumping. Some of the cadmium in these products will be released to the environment, the extent of which depends on disposal method, control technologies applied and other factors.

V. Cadmium issues in developing countries

21. As awareness of the adverse impacts of cadmium has increased, many uses have been reduced significantly in industrialized countries. In addition, as public awareness has grown, waste management systems have increasingly been put in place in industrialized countries to reduce releases of cadmium into the environment. That said, however, some of the uses of cadmium which have been phased out in industrialized countries have continued in developing countries. In addition, use of cadmium has continued or increased in some less developed regions or countries, e.g., in plastics or in paints. Regulations and restrictions are less comprehensive or less well enforced in some developing regions. This has resulted in some of the health and environmental risks, local and regional, that accompany the use, management (including collection, storage, recycling and treatment) and disposal of products containing cadmium. These hazardous disposal practices include open burning and indiscriminate dumping in sensitive ecosystems such as rivers and wetlands.

22. Another issue faced by developing countries is the export of new and used products containing cadmium, including electronic equipment and batteries, to those countries which lack the capacity to manage and dispose of the cadmium in these products in an environmentally sound manner at the end of their life. Another problem is posed by products containing cadmium that may cause exposure through normal use, such as certain toys.

VI. Levels and time trends in air and deposition

23. Most of the identified monitoring measurements for atmospheric cadmium concentrations and deposition come from Europe and the United States of America; data from Japan, China, Canada, Antarctica and New Zealand are, however, also available. Data are very limited to assess trends. In Europe, however, between the early 1990s and 2003, average concentrations of cadmium in air

decreased by about 50 per cent in central and north-western Europe. Measured concentrations in precipitation decreased by about 65–75 per cent in central and north-western Europe. From 1990 to 2003 in the northern part of Europe and from 1990 to 1996 in a few North American locations, there were no observable trends in concentrations of precipitation.

24. Some modelling has been performed, mostly in Europe, to estimate deposition rates. When reported emissions are used in the models, they generally underestimate deposition (compared to measured data). The underestimation is believed to be due to the failure to include natural emissions and re-emissions of historical releases in the models and to uncertainties in reported emissions.

25. Measured air levels tend to be much higher near sources and in urban areas compared to remote locations. For example, in remote areas of the United States of America, atmospheric cadmium concentrations are generally below 1 ng/m3. Levels in urban air are significantly higher (3–40 ng/m3). Over the Great Lakes, atmospheric cadmium concentrations ranged from 0.2 to 0.6 ng/m3. These data indicate that atmospheric cadmium concentrations are much higher close to sources of emissions and that long-range transport results in much lower levels in the atmosphere.

26. Cadmium concentrations in Spitsbergen, Norway, did not exhibit any noticeable trend over the period 1994–2003. Cadmium appears to deposit more readily in the Arctic than other particulate elements. In these areas, however, the total cadmium deposition and atmospheric depositions is much lower than in industrial areas.

27. The main factors affecting the range and deposition of cadmium emissions include: characteristics of emission sources (higher outlets and higher emission temperatures result in higher emission plumes and, therefore, longer transport ranges); physical and chemical forms of cadmium in the atmosphere: large particles deposit within short ranges, small particles may be transported further; and meteorology (precipitation and wind speed), terrain, atmospheric stability, and other factors.

VII. Human exposure pathways and effects

28. Cadmium is a non-essential and toxic element for humans. Attention is drawn to the following:

- The kidney is considered the critical target organ for toxicity of cadmium in humans. The main critical effects include an increased excretion of proteins in urine as a result of proximal tubular cell damage. The severity of the effect depends on duration and magnitude of exposure
- Skeletal damage is another critical effect of chronic cadmium exposure at levels somewhat higher than those for which kidney proteinuria is an early effects indicator
- Cadmium is a human carcinogen by the inhalation route. Epidemiological data from occupational settings confirm lungs being the primary target organ. Cadmium is not considered a carcinogen by ingestion
- Cadmium is mainly stored in the liver and kidneys. Excretion is slow, with a very long half-life (decades) in the human body. Cadmium concentrations in most tissues increase with age

29. There are multiple sources of cadmium exposure in the general population. Attention is drawn to the following:

- Food accounts for approximately 90 per cent in the general, non-smoking population
- Cadmium in crops is due to the uptake of cadmium from soils and the rate of uptake is influenced by factors such as soil pH, salinity, humus content, crop species and varieties and the presence of other elements (e.g., zinc)
- Less than 10 per cent of the total exposures among general populations occur due to inhalation of low levels of cadmium in ambient air and through drinking water
- The kidney burden resulting from cumulative exposure to cadmium can be assessed by measuring cadmium in urine

30. Some population groups are especially vulnerable to increased exposure and uptake of cadmium. Attention is drawn to the following:

- Cadmium occurs in all food, but agricultural crops (particularly irrigated rice) generally account for most of the intake. Vegetarians and high cereal-consuming and pulse-consuming groups are likely to have higher exposures compared to the general population
- People with a high intake of shellfish and organ meat from marine animals may have a particularly high intake of cadmium
- People with low body iron stores, especially pregnant women, or low zinc intake will exhibit higher rates of cadmium uptake
- People with other nutritional deficiencies may also be at risk
- Tobacco is an important source of cadmium uptake in smokers and may also affect non-smokers through passive exposure to secondary smoke
- People living in the vicinity of industrial sources and other point sources of cadmium release can be exposed to an increased level of cadmium

31. Certain population groups are vulnerable and especially susceptible to cadmium. Attention is drawn to the following:

- People who have medical detriments from a range of other clinical conditions, particularly those related to renal insufficiency (e.g. diabetes) and multiparous women with inadequate nutrition, are more susceptible
- Renal efficiency normally decreases with age and can be exacerbated by exposure to cadmium

32. The level of dietary exposure can exceed the guidelines set by the United Nations Food and Agriculture Organization (FAO) and the World Health Organization (WHO). Attention is drawn to the following:

- According to available data, the average weekly intake of cadmium from food in most countries is within the range of 0.7–2.8 µg/kg body weight
- Although available data indicate that most people have intake levels below the provisional tolerable weekly intake (PTWI) (7 µg/kg body weight per week), WHO recognizes that the margin between the PTWI and the actual weekly intake of cadmium by the general population is small, less than 10-fold, and that this margin may be even smaller in smokers
- In some populations at high risk, the margin may be non-existent

VIII. Impacts on the ecosystem

33. Cadmium is a non-essential heavy metal. Some cadmium compounds are relatively water soluble, mobile in soil and bioavailable, depending on the water and soil chemistries. It tends to bioaccumulate in organs such as the kidney and liver of vertebrates, but aquatic invertebrates and algae can also build up relatively high concentrations. Effects on birds and mammals are mainly due to kidney damage. In sea birds and marine mammals in particular, cadmium accumulates to relatively high levels.

34. In terrestrial ecosystems, soil micro-organisms and plants are more sensitive to cadmium than soil invertebrates. Both invertebrates and plants can accumulate cadmium. Predators feeding on such soil invertebrates can introduce cadmium into the food chain, which suggests a risk of secondary poisoning through the food chain from worms to higher trophic levels (birds or mammals). The accumulation of cadmium by plants results in this contaminant entering the human food chain. In some European areas, the cadmium concentrations measured and estimated are exceeding the threshold concentration for adverse effects on terrestrial ecosystems. In the United Nations Economic Commission for Europe region, available information indicates that levels of cadmium in terrestrial wildlife are generally low and do not exceed thresholds for effects.

35. Aquatic fresh and marine invertebrates are the organisms most sensitive to cadmium. The dissolved cadmium concentrations measured in some European waters (mainly rivers) are exceeding the threshold concentration producing adverse effects of cadmium in the aquatic ecosystem. Some studies suggest that levels in water, sediment and soil are at or above known biological effect levels. Despite relatively high levels of cadmium in seabirds and marine mammals in Greenland, no evidence has been found of effects in ringed seals with very high cadmium levels in their kidneys. Arctic seabirds in general are known to accumulate high levels of cadmium found naturally in the marine environment and are therefore considered to be not as sensitive as terrestrial birds. Kidney damage has, however, been reported in wild colonies of Arctic pelagic seabirds having cadmium levels of 60-480 µg/g in the kidney. Spatial distribution of cadmium in marine biota appears to be driven by regional geology or geochemistry. Monitoring data on cadmium in the Arctic abiotic and biotic environment to date, however, provide no conclusive evidence of trends or effects.

IX. Data gaps

36. A number of data gaps and needs have been identified. Attention is drawn to the following:

- The need to develop and improve exposure assessments and use and release inventories, especially for developing countries
- The need for information to improve understanding of the inconsistencies between official reported emissions and observed cadmium concentration and depositions
- The need for substance flow analysis in the economy on a national and global basis in order to identify the sources of risk
- The need for hemispheric modelling and modelling for other countries and continents, and for better understanding of ocean transport, re-emissions and natural releases and data to support such modelling
- The need for assessment of the extent of risks to humans, the ecosystem or animals from exposure to cadmium, the role of long-range environmental transport, the contribution of anthropogenic versus natural sources and the influence of local, regional, and global sources
- Relative contributions of anthropogenic and natural of cadmium emissions on a global basis
- The need to monitor and assess cadmium levels in various media (such as soil and sediment) and data associated with impacts on humans, ecosystems and animals, including impacts from cumulative exposures to different forms of cadmium, as well as further emission data that help overcome the uncertainties in the results of the current models
- The need to collect data regarding accidental spills from mine tailings on a global scale and the real extent of these events, especially in developing countries, where capacity building is needed
- The need for real information about the quantities of cadmium disposed of in the environment, especially in developing countries, where the open burning of cadmium-containing products is a common practice, which results in atmospheric emissions
- The need to improve the information on the level of contamination of drinking water by cadmium as a result of leaching from landfills, especially in developing countries
- Transport by rivers to marine environments on a global scale
- The need to collect data on concentration levels in large migrating marine mammals
- The need for better understanding of the health risks due to exposure to cadmium and various factors that affect that risk
- The need to investigate the magnitude of natural emissions versus anthropogenic emissions, in particular with regard to particle size
- The need to examine the global flow of cadmium in products