GEF Guidance on Emerging Chemicals Management Issues in Developing Countries and Countries with Economies in Transition

Scientific and Technical Advisory Panel

An independent group of scientists which advises the Global Environment Facility

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A STAP Advisory document
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Prepared on behalf of the Scientific and Technical Advisory Panel (STAP) of the Global Environment Facility (GEF) by Hindrik (Henk) Bouwman

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Disclaimer

This document attempts to define, identify, evaluate and prioritize emerging chemicals management issues (ECMI) for Developing Countries and Countries with Economies in Transition, as a first step in helping the GEF plan its allocation of resources to help anticipate, prevent, reduce and/or minimize adverse impacts of chemicals on human health and the environment. It is based on the 2011 survey results of members of the Society of Environmental Toxicology and Chemistry, and does not seek to suggest that the ranked chemicals priorities will remain static over time. Instead, it should be viewed as a current snapshot of expert opinion on the issue, with results having perhaps a five year life span of relevance.The views contained herein do not necessarily reflect the views of the Global Environment Facility, or its Scientific and Technical Advisory Panel.

Citation

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About STAP

The Scientific and Technical Advisory Panel comprises six expert advisers supported by a Secretariat, which are together responsible for connecting the Global Environment Facility to the most up to date, authoritative, and globally representative science.

http://www.unep.org/stap

Foreword

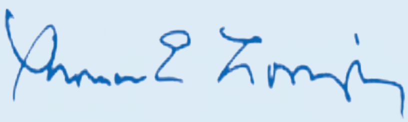
This report was predicated by GEF programmatic mandate on the promotion of sound chemicals management, as well as observations on the global chemicals landscape that alert us to the enormity of the challenge of sounds chemical management.

The Chemicals Abstracts Service (CAS) (http://www.cas.org/) states that there are 60 million registered organic and inorganic substances in the world. Of that, only a fraction have been tested and inventoried by chemicals oversight bodies. For example, the USEPA maintains an inventory of approximately 84,000 commercially important chemicals; and of those, a smaller fraction still have been tested for their toxicity, including the vast majority of those categorized as "high volume".

In the face of rapid globalization and demand for products, increased trade, expansion of manufacturing into Developing Countries and Countries with Economies in Transition (CEIT), new chemicals, uses, or products, along with an increased awareness of real or potential negative impacts of chemicals, the last two decades has also seen the rapid implementation of a number of regional and international agreements regarding chemicals management, which have focused concerns on the need for a globally effective and sustainable chemicals management process. One particular chemicals management response of note, is the Strategic Approach to International Chemicals Management (SAICM), which pays particular attention to chemicals, products, uses, releases, or wastes that are currently not under consideration or taken up by existing Multilateral Environmental Agreements (MEAs).

Apart from the potential of human health and environmental effects from chemicals, other aspects such as increased transboundary movement of chemicals through trade or environmental release have also come to the fore. As various MEAs wade in to manage and regulate some discreet categories of chemical, there are increased concerns and awareness about those that are not covered, or only partially covered or recognized by regulation. These are commonly and collectively termed Emerging Chemical Management Issues (ECMIs).

This document seeks to attempt definition of the ECMI, and to identify, evaluate and prioritize ECMIs in relation to the likely chemical management needs of Developing Countries and CEIT. In doing so, it is hoped that it will help with the allocation of additional resources and support from the GEF within its mandate to anticipate, prevent, reduce and/or minimize adverse impacts of chemicals on human health and the environment.



Thomas E. Lovejoy
Chair, Scientific and Technical Advisory Panel

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List of Abbreviations

ABNJ:	Areas beyond National Jurisdiction
AFFF:	Aqueous film forming foam
APEOs:	Alkylphenol ethoxylates
BAT:	Best available technologies
BE:	Benzoylecgonina
BEP:	Best Environmental Practice
BPA:	Bisphenol A
CDC:	Center for disease control, Atlanta, USA
CEIT:	Countries with economies in transition
DC&CEIT:	Developing countries and Countries with economies in transition (In tables only)
DDT:	Dichloro diphenyl thichloroethane
DEP:	Di ethyl phtalate
DHEP:	Diethylhexylphtalate
DinBP:	Di n butyl phtalate
DiNP:	Diisosonylpthalate
DPSIR:	Driver- Pressure –State- Impact and Response
DTIE:	United Nations Environment Programme Division of Technology, Industry and Economics
ECMIs:	Emerging Chemicals Management Issues
EDC:	Endocrine disrupting Chemical
EDDP:	Ethylidene- 1,5-dimethyl-3,3-diphenylpyrrolidine
EU:	European Union
GEB:	Global Environmental Benefit
GEF:	Global Environmental Fund
HPLC MS:	High Performance Liquid Chromatography Mass spectrometry
IFCS:	International Forum on Chemical Safety
IMO:	International Maritime Organisation
ISAO:	International Sea Affairs Organisation
ITC:	US Interagency Testing Committee
LCA:	Life Cycle Analysis
LRT:	Long Range Transport
MEA:	Multilateral Environmental Agreement
NP:	Nonylphenol
NPEO:	Nonylphenol ethoxylate
OECD:	Organisation for Economic Co-operation and Development

OP:	Octylphenol
OPEO:	Octylphenol ethoxylate
PAH:	Poly cyclic Aromatic Hydrocarbon
PBB:	Polybrominated biphenyl
PBDE:	Polybrominated diphenyl ether
PBT:	Persistent Bio accumulative Toxic Chemical
PC:	Polycarbonate
PCB:	Polychlorinated biphenyl
PCDD/F:	Polychlorinated Dioxin/Furan
PFC:	Perfluorinated compound
PFOS:	Perfluoroctane sulfonic acid
PFOA:	perfluorooctanoic acid
PIC:	Prior Informed Consent
PNEC:	Predicted non effect concentration
POP:	Persistent Organic Pollutant
PPCP:	Pharmaceuticals and personal care product
PVC:	polyvinylchloride
REACH:	Registration Evaluation and Authorisation of Chemicals
SAICM:	Strategic approach to International Chemicals Management
SC:	Stockholm Convention
SCCPs:	Short Chain Chlorinated Paraffins
SETAC:	Society of Environmental Toxicology and Chemistry
STAP:	Scientific and Technical Advisory Panel
STP:	Sewage treatment plant
TBT:	Tributyltin
TPhTAc:	Triphenolstannyl acetate
UNECE:	United Nations Economic Commission for Europe
UNEP:	United Nations Environment Programme
UNIDO:	United Nations Industrial Development Organization
UNITAR:	United Nations Institute for Training and Research
USEPA:	United States Environmental Protection Agency
WHO:	World Health Organization

Executive Summary

The last two decades has seen the rapid implementation of a number of regional and international agreements regarding chemicals management. At the same time however, rapid globalization and demand for products, increased trade, expansion of manufacturing into Developing Countries and Countries with Economies in Transition (CEIT), new chemicals, uses, or products, coincided with an increased awareness of real or potential negative impacts of chemicals, and has focused concerns on the need for a globally effective and sustainable chemicals management process. The Strategic Approach to International Chemicals Management (SAICM) is the response to these concerns, especially regarding chemicals, products, uses, releases, or wastes that are currently not under consideration or taken up by existing Multilateral Environmental Agreements (MEAs). Recent scientific advances highlighted the potential of human health and environmental effects from chemicals. Other aspects such as increased transboundary movement of chemicals through trade or following release have also come to the fore. Some of these chemicals concerned are already regulated or recognized by existing MEAs or MEAs under negotiation. However, there are issues highlighted by recent and current research, as well as increased concerns and awareness that are not or only partially covered or recognized by regulation. These are commonly and collectively termed Emerging Chemical Management Issues (ECMIs). For this document, ECMI is defined as any potential or recognized human health and/or environmental effects concern associated with chemical(s) whose management is not or only partially addressed by existing MEAs. The term ECMI does not have any legal standing, recognition, or implication. Its use is entirely as collective shorthand.

The immediate goal of the GEF through its present chemicals program is *to promote the sound management of chemicals throughout their life-cycle in ways that lead to the minimization of significant adverse effects on human health and the global environment*. This report will identify, evaluate and prioritize ECMIs in relation to the likely chemical management needs of Developing Countries and CEIT such that additional resources and support from GEF within its mandate will anticipate, prevent, reduce and/or minimize adverse impacts on human health and the environment.

Twenty-two ECMIs were identified and described using various criteria listed below. The ECMIs covered by this study were PAHs, Arsenic, Bisphenol A, Alkylphenols, Phthalates, Organotins, Heavy metals, Nanoparticles and nanomaterials, Lead in paints, Inorganic fertilizer, Cadmium in fertilizer, Pharmaceuticals and personal care products (PPCPs), Illicit drugs, Food additives, Endocrine disruption, Mixture effects, E-waste, Marine debris, Ammunition, conflict and the legacies of war, Mine waste and drainage, Sewage, and Open burning.

The ECMI Concern Criteria

1. **Concern to Developing Countries and CEIT:** Most of the information regarding ECMIs comes from Developed Countries. Judgment was made, based on the insight and expert knowledge, at what level the specific issue is or might be a concern to Developing Countries and CEIT. Considerations here also included whether appropriate and effective regulatory mechanisms were present.

2. **Geographical scale of impact:** ECMIs with clearly current isolated concerns scored 'Local'. This criterion is semi-independent of the trans-boundary criterion, as potentially, an ECMI shared by small states may cover only a small geographic region. Its impact might be significant even when geographically restricted, and the text should be consulted for clarification. Small Island states were not considered as 'small', as they often cover large territories.

3. **Trans-boundary issues:** In line with the GEF mandate, ECMIs that have clear or potential impact across at least one national border were included. Since there are regions with small states grouped together, very few concerns were eliminated on this criterion. However, some ECMIs had no information on this issue, and were included based on potential cross-boundary concerns, but rated as unknown.

4. **Impact on ecosystems:** This criterion included all concerns relating to the whole range of issues between genetic implications to ecosystem functioning. Consideration for scoring was much the same as for human health.

5. **Impact on human health:** Impacts on humans other than health were not considered here. Human health was one of the major issues that became apparent when considering ECMIs. Again, proven or potential impact was considered.

6. **Climate change impacts:** The production, use, disposal, environmental and health impacts and related aspects may either have an effect on climate change, or be affected by climate change. For many of the ECMIs, very little is known about this criterion.

7. **Economic and social issues:** The production, use, effects and management of a particular ECMI may also affect economic and social issues, or be affected by it.

8. **Intervention priority:** Based on a number of considerations including human health and environmental impacts, a judgment was made on the urgency for appropriate and effective intervention. ECMIs that scored low in the previous criteria normally would score lower for this criterion as well. However, the score may need adjustment when new information becomes available.

The 22 ECMIs were identified without attempting watertight separation between them. The overlaps and interactions between the ECMIs were examined in order to identify where interventions on a specific ECMI would also address and potentially mitigate other ECMIs. Co-benefits with multiple ECMIs would therefore add to cost-effectiveness of interventions. The report also looked at crosscutting issues such as poverty, lack of effective regulation, climate change, and biodiversity.

Prioritization was done by the Society of Environmental Toxicology and Chemistry (SETAC), surveying their members from Developing Countries and CEIT. The impact of each ECMI on each of the concern criteria were surveyed, tabulated, and ranked per region and all regions combined. The following regions were chosen: Central and South America, Africa, Asia, Eastern Europe, and Oceania. Useful responses were received from 135 respondents. The accompanying table presents a summary of the rankings as Aggregate concern. The Aggregate concern was derived by ranking the responses of surveyed SETAC scientists from Developing Countries and CEIT, using questions based on specific ECMI criteria, all designed to elicit the perceived concern and impacts of each ECMI under review. All results should be interpreted with reference to the accompanying text in the main document. The main report presents additional information (including an assessment of the interactions between the ECMIs) and recommendations that will assist in interpreting the findings of this report.

Results and Conclusions

Based on the analyses, the results of the survey, and comments from the respondents, the following specific and general results and conclusions are presented.

General

- The world is experiencing an increasing complexity of chemical management issues.
- The scope and extent of some or most ECMIs are increasing, resulting in more pressures on human health and the environment.
- Some of the ECMIs under consideration (such as heavy metals and PAHs) have been recognized as important issues in the past, but their impacts are now either increasing and/or its threats are now better understood.
- Many of the ECMIs represent a serious environmental and human health threat, especially in many of the Developing Countries and CEIT that lack effective regulation and/or enforcement.
- This report analyzed crosscutting issues and interactions between the ECMIs. The interactions and crosscutting issues involved create complexities that make interventions to address an ECMI in isolation almost impossible.
- ECMIs, if not addressed timely and adequately, will increasingly become a drag on social wellbeing and stability, environmental sustainability, and economic progress.
- A lack of regulation, capacity, and enforcement also allows deliberate disregard for the common good, and may result in the compromise of human health and environmental integrity.
- Some ECMIs, such as Cadmium in fertilizers, Lead in paints, Illicit drugs, Food additives deliberately used for adulteration, and Ammunition and conflict, despite adequate evidence and well-known health and environmental hazards, are characterized by at least some deliberate disregard of the common good. The continued and regular disclosures of food and feed adulteration in Developed Countries, as well as in Developing Countries and CEIT, probably represents only a small proportion of actual cases.
- Interventions on specific issues in countries and regions on a specific ECMI may have unintended consequences elsewhere. For example, closing down (or regulating) illegal or harmful E-waste processing in one country or region may result in such processing moving somewhere else. E-waste and possibly other such ECMIs, although a regional activity, should therefore be considered a global ECMI as the activities might shift elsewhere. The high Aggregate concern ranking of E-waste in Oceania might already be an indication of such shifts, but that needs further investigation.
- Geology-related ECMIs (mining and fertilizers) have mainly local impacts but the products of these activities are shipped globally. Spreading the advantages of the products globally therefore qualifies localized ECMI impacts as global although the production impacts are localized. Corrective interventions on a localized level will therefore have global environmental benefits.
- Copying the regulations from Developed Countries by Developing Countries and CEIT by may be misdirected (perhaps even counter-productive), and may in some cases not be needed if a particular ECMI is not relevant or present.
- Most knowledge on ECMIs is derived from Developed Country investigations, but lack accurate extrapolation power to Developing Countries and CEIT scenarios. However, even with this lack of local knowledge, it is obvious, based on knowledge from elsewhere, that intervention on certain ECMIs is required, and that management options are available.
- Many ECMIs are more common in (and sometimes almost exclusive to) Developing Countries and CEIT. Therefore, research and monitoring capacity that are specific to the needs of Developing Countries and CEIT is needed that are less reliant on Developed Country experiences and needs. Developed Country research is often geared towards their own priorities and situations, possibly skewing research collaboration, donor aid, and diplomatic efforts towards ECMIs that are shared rather than characteristic of Developing Countries and CEIT.

- Interventions, mitigations, alternatives, and disposal options are often available, but may need local adaptation and/or proof of implementability.
- Some ECMIs are partially addressed by some form of local, regional, or global intervention or instrument, indicating effective mitigation experience and some capacity to intervene.
- Existing multilateral modes of intervention and assistance needs to be explored further

Regional and all-regional ECMIs ranked on Aggregate concern

ECMI	Central & South America	Africa	Asia	Eastern Europe	Oceania	**All regions - Oceania**	**All regions + Oceania**
Heavy metals	1	1	1	1	3	**1**	**1**
PAHs	3	2	2	4	2	**2**	**2**
Mixture effects	2	7	6	2	15	**3**	**4**
Open burning	5	5	3	3	1	**4**	**3**
Endocrine disruption	4	12	4	7	12	**5**	**6**
Sewage	6	10	12	6	5	**6**	**5**
Inorganic fertilizer	8	9	13	5	7	**7**	**7**
Arsenic	10	11	5	10	9	**8**	**9**
E-waste	13	3	7	14	7	**9**	**8**
PPCPs*	7	8	15	11	14	**10**	**11**
Mine waste	11	14	11	8	10	**11**	**10**
Lead in paints	17	4	8	15	16	**12**	**13**
Illicit drugs	9	6	18	19	17	**13**	**14**
Cadmium in fertilizer	12	15	10	16	10	**14**	**12**
Food additives	15	13	14	13	21	**15**	**16**
Phthalates	16	17	16	9	20	**16**	**17**
Bisphenol A	19	20	9	20	18	**17**	**19**
Organotins	18	21	17	12	12	**18**	**18**
Marine debris	14	19	19	21	4	**19**	**15**
Alkylphenols	20	18	20	21	18	**20**	**21**
Ammunition/conflict	22	16	22	18	6	**21**	**20**
Nanoparticle/material	21	22	21	17	22	**22**	**22**

**Pharmaceuticals and personal care products*

Specific

- An assessment of interactions between ECMIs (e.g. there is an interaction between PAHs and Mixture effects) showed that Mixture effects had the most interactions with other ECMIs, followed by Endocrine disruption, Heavy metals, Marine debris, Sewage, and E-waste.[1]
- In Developing Countries and CEIT, Heavy metals was the top priority of Aggregate concern, followed by PAHs, Mixture effects, Open burning, Endocrine disruption, Sewage, and Inorganic fertilizer.
- The ECMI ranked lowest on Aggregate concern were Phthalates, BPA, Organotins, Marine debris, Alkylphenols, Ammunition and conflict, and Nanoparticles and nanomaterials.
- In Central and South America, Heavy Metals was ranked highest on Aggregate concern, followed by Mixture effects, PAHs, Endocrine disruption, Open burning, and Sewage. Highest-ranked intervention priorities were Heavy metals, Mixture effects, Sewage, PAHs, and PPCPs.

1 See Table 6.2 in the report for the full pattern of interactions.

- In Africa, Heavy metals and PAHs were highest ranked highest on Aggregate concern, followed by E-waste, Lead in paints, Open burning, and Illicit drugs. In terms of intervention priority, E-waste was ranked highest, followed by Heavy metals, Open burning, Illicit drugs, and Lead in paints, and Inorganic fertilizer.
- In Asia, Heavy metals was ranked the highest on Aggregate concern, followed by PAHs, Mixture effects, Open burning, and Endocrine disruption. As intervention priorities, Heavy metals and Open burning were ranked 1st and 2nd, followed by E-waste and Inorganic fertilizer. Arsenic and Mixture effects were jointly ranked 5th. Joint ranking of ECMIs may indicate the need for sub-regional prioritization. Arsenic for instance, may achieve a much higher ranking in some sub-regions.
- In Eastern Europe, Heavy metals topped the Aggregate concern list, followed by mixture effects, Open burning, PAHs, Inorganic fertilizer, and Sewage. Intervention priorities were slightly different from the other regions. Mine waste was top-ranked, followed by Sewage, and Inorganic fertilizer (jointly 2nd), Heavy metals and illicit drugs (jointly 4th), and PPCPs and Open burning (jointly 6th). Presuming that Eastern Europe is further along the developmental track, intervention priorities such as Sewage and Mine waste might increase in Intervention priority in other regions once their top priorities have been dealt with.
- Only four responses were received for Oceania. The results should therefore be treated with caution and the survey may need to be repeated. Highest-ranked aggregate priorities were Open burning, PAHs, Heavy metals, Marine debris, Sewage, and Ammunition and conflict. Intervention priority was highest for PAHs, PPCPs and Ammunition and conflict (jointly 1st), followed by Open burning, E-waste, Marine debris, and Mine waste (also jointly). Open burning and PAHs seems an obvious joint target for intervention.
- Open burning and PAHs are associated ECMIs with high intervention priorities and possibilities for mitigation by management. Some MEAS already address PAHs, but only on a regional scale.

Considerations

- Regional Aggregate concern rankings of ECMIs were done according to eight different (but overlapping) ECMI concern criteria. It is to be expected that ECMIs in different regions may have similar rankings but for different reasons or concerns. Interpretation and further actions need to take account of the differences in the reasons or concerns.

- Many of the ranked ECMIs are interlinked. For example, a reduction in Open burning will also reduce PAHs, Heavy metals, Endocrine disruption, and Mixture effects. In turn, this will also reduce impacts on Human health, Ecosystems, Economic and social interactions, and Climate change interactions.

- The differences between Aggregate concern rankings and Intervention priorities (presented in the main report) indicate that some ECMIs should be addressed over a longer term. However, addressing the higher intervention priority ECMIs will also reduce the impacts of some of the higher-ranked Aggregate concern priorities due to interlinkages as represented in Table 6.2 of the main report.

- Lower-ranked ECMIs may be a greater problem than represented here due to insufficient data and science.

- It should also be kept in mind that lower-ranked ECMIs could be as big a problem in Developing Countries and CEIT as in Developed Countries, but that higher-ranked ECMIs present an even larger challenge. Lower-ranked ECMIs are therefore not necessarily less of a problem, but are overshadowed by others.

- Respondents consistently ranked the effects-based ECMIs (Endocrine disruption and Mixture effects) very high on Aggregate concern. This represents a realization that humans, biota and ecosystems deal with a myriad of chemicals in different combinations (the 'chemical soup'), with multiple effects at sub-lethal levels.

- Many of the lower-ranked ECMIs are also subsumed within higher Aggregate concerns ECMIs criteria such as Endocrine disruption and Mixture effects. Addressing the higher-ranked ECMIs will most likely address some of the lower ranked ECMIs such as Bisphenol A, Phthalates, and Alkylphenols. Respondents signaled that a piece-meal approach would have lesser benefits than an integrated approach.

- Some ECMIs were ranked higher on Aggregate concern, but lower on Intervention priority (Intervention priorities are presented in the main text). This dichotomy can be explained by considering that as countries are dealing with ECMIs of immediate high-concern as part of their development trajectories, other ECMIs will then attain higher priority. Phrased differently, while an ECMI such as plasticizers may have as great a concern and impact in Developing Countries and CEIT as in Developed Countries, there are even greater concerns about other ECMIs such as PAHs and Heavy metals in Developing Countries and CEIT. While management interventions are adapted to address the highest concern ECMIs, Developed Countries develop mitigation measures from which Developing Countries can subsequently learn from and adopt. How to balance competing concerns remains a challenge for the international community.

Recommendations

The interactive and complex nature of the 22 ECMIs under consideration indicates that addressing these problems will be a challenge. The values represented by the economic, social, environmental, political, and health constituents need to be balanced in such a way that none are deprived, but all are strengthened. However, expectations may need to be compromised and re-aligned by the respective economic, social, environmental, political, and health custodians to prevent irreparable damage to the environmental matrix and its ability to support human life, dignity, and quality. That problems should be anticipated and prevented, rather than managed after the fact should eventually be the aim, but there are current pressing problems (the high-rank ECMIs) to be addressed first. There is, however, good reason to use the current challenges as opportunities to get into place the people and systems that will eventually enable prevention and improvement. Within the context of the ECMI challenges and priorities identified, the following are proposed:

- Consideration should be given to Heavy metals, Open burning, and PAHs as high priority targets for concerted international intervention. This issue probably represents the largest unaddressed chemical threat currently experienced in Developing Countries and CEIT.

- Since PAHs are already addressed by at least one regional MEA (the United Nations Economic Commission for Europe's Convention on Long-range Transboundary Air Pollution (LRTAP)), consideration could be given to extending or replicating LRTAP, but also to reduce human exposure to PAHs from open fires used for cooking and heating in Developing Countries and CEIT.

- It seems prudent that urgent attention be given to mitigating Mixture effects and Endocrine disruption. Since Endocrine disruption can be seen as subsumed into Mixture effects, planning can be directed by combining these effects-based ECMIs as a topic for international concerted intervention. Consideration should also be given to the interaction Table 2.6, as many of the lower-ranked ECMIs would be involved in a higher level effects-based ECMI that combines Mixture effects and Endocrine disruption.

- A more detailed assessment of each of the highest-ranked Aggregate concern ECMIs (Heavy metals, PAHs, Mixture effects, Open burning, Endocrine disruption, Sewage, Inorganic fertilizer, Arsenic, E-waste, and PPCPs) should be conducted on a global and regional basis to better investigate *inter alia* the conditions, intervention options, interactions with other ECMIs, global environmental and health benefits, and management options. This will serve as ECMI-specific frameworks for detailed intervention planning. Greater specific input should be sought from role players other than scientists, such as policy makers, industry representatives, civil society, gender involvement (a GEF priority), and NGOs. Institutions such as UNEP and SAICM are already working on guidance for ECMIs such as Endocrine disruption, some of the heavy metals, and E-waste. GEF/STAP has also produced guidance on Marine debris relevant to Developing Countries and CEIT.

- Serious and immediate attention should be given to implementing or strengthening regional and continental research and monitoring programs (such as GAPs and MONET), for ECMIs not currently covered by sometimes narrowly-mandated MEAs. Based on identified priorities, country-specific and regional research capacity must be enhanced to tackle identified priority ECMIs, but also taking note of the interactions indicated in Table 2.6.

- An ECMI observatory mechanism (similar to the European Risk Observatory) could be established that will assist in the timely translation of new scientific knowledge and new ECMIs (such as ECMIs on the horizon) into how they might affect Developing Countries and CEIT. Such an observation mechanism would be able to advise Developing Countries and CEIT, IGOs, and funding agencies on where research may be directed, and how this may be accomplished. Currently, many MEAs support fractionated investigations based on narrow mandates without the option of investigating emerging issues before a ponderous process of negotiations has been completed. This situation hampers the ability of Developing Countries and CEIT to eventually taking over more responsibility to address ECMIs and other environmental issues.

- This assessment only ranked the ECMIs, but did not attempt to quantify the issues on the ground. A better understanding of the amounts, activities, emission rates, sensitive communities, transboundary issues, areas to be rehabilitated, and other criteria need to be understood. Such a quantification exercise should incorporate all other major chemicals management issues such as POPs and mercury for which there are already adequate data.

- Consideration should also be given on how to interface the results from this assessment with other chemicals-focused assessments by institutions such as UNEP. UNEP, for instance, conducts the Chemicals outlook.

- An ECMI survey could be conducted every five years to track impact of interventions and to determine any changes in priorities, with a greater effort to collect regional specific information.

Specific Guidance to The GEF

Because this assessment looked at Emerging Chemicals Management Issues, it was deliberately undertaken without direct reference to current GEF activities to encompass the entire scope of the chemical problems faced by Developing Countries and CEIT. This assessment deliberately excluded all issues already dealt with by existing MEAs, or MEAs under development to allow the identification of emerging (or perhaps long-neglected) needs in addition to those already addressed by MEAs and currently serviced by The GEF. STAP is in a good position to conduct such high-level guidance as its mandate from The GEF Council is focused on Developing Countries and CEIT considering transboundary issues and Global Environmental Benefits.

With this ECMI assessment, STAP has identified specific Emerging Chemical Management Issues that, when addressed, will enhance the environmental protection and provide global benefits to societies, regions, and ecosystems. From this assessment, it is obvious that Heavy metals, PAHs, and Open burning would be prime and immediate intervention candidates that could be added to the current concerns addressed by the Chemicals Portfolio of the GEF.

The GEF does not operate in isolation. In partnership with the GEF Agencies within their respective mandates, through the GEF Chemicals Task Force, it is proposed that urgent attention be given to investigate how this assessment could inform the next replenishment. The GEF is an evolving organization that is responsive to the needs of its clients and donors, and associated MEAs. With a refined chemicals focus, the GEF will remain the prime funding organization for Developing Countries and CEIT. With this in mind, the following is proposed to GEF Council:

- This assessment is to inform GEF Council for the next replenishment of the GEF.
- To consider initiating the development (where appropriate in partnership with other Agencies) of specific intervention guidance on:
- To consider initiating the development (where appropriate in partnership with other Agencies) of specific intervention guidance on:
  - Heavy metals
  - PAHs and Open burning
  - Mixture effects (incorporating Endocrine disruption)
  - Inorganic fertilizers
  - Swage
  - Arsenic
  - E-waste
- To consider developing guidance on how the chemicals management issues (current and new) can interface with the other Focal Areas of the GEF, as well as with agendas such as urbanization and human health that are currently not a focus within the GEF. The Marine Debris guidance is an example where the GEF focal areas of Chemicals, International Waters, and Biodiversity interfaced while also considering health and urbanization.

CHAPTER 1

Introduction

The last two decades has seen the rapid implementation of a number of regional and international agreements regarding chemicals management. They all have the aim to protect human and environmental health by limiting or eliminating releases by, *inter alia*, regulating production, trade, uses, wastes, and exposures. Three well-known Multilateral Environmental Agreements (MEAs) in this regard are the Rotterdam (focusing on trade in hazardous chemicals), Basel (focusing on transboundary movement of hazardous wastes), and Stockholm (focusing on persistent organic pollutants or POPs) Conventions. These three and many other such agreements use Annexes to list specific concerns with respect to specific chemicals, products, or waste categories. These Annexes are under continuous or frequent review and are regularly amended, normally resulting in the expansion of the number of chemicals, products, or waste categories under their remit. Concurrently, REACH (Registration, Evaluation, and Authorisation of Chemicals) has strengthened chemicals management in the EU.

At the same time however, a number of factors (rapid globalization and demand for products, increased trade and agriculture, expansion of manufacturing into Developing Countries and Countries with Economies in Transition (CEIT), and new chemicals, uses, or products) coincided with an increased awareness of real or potential negative impacts of chemicals. These interactions have focused concerns on the need for a globally effective and sustainable chemicals management process. The Strategic Approach to International Chemicals Management (SAICM) is the response to these concerns, especially regarding chemicals, products, uses, releases, or wastes that are currently not under consideration or taken up by existing MEAs.

Recent scientific advances have highlighted the potential of human health and environmental effects from chemicals in addition to the well-known acute, sub-acute, reproduction, and cancer endpoints normally used to characterize chemical-specific hazards. Other aspects such as increased transboundary movement of chemicals through trade or following release have also come to the fore. Some of these chemicals concerned are already regulated or recognized by existing MEAs, but there are issues highlighted by recent and current research, as well as increased concerns and awareness that are not or only partially covered or recognized by any regulation or regulation. These are commonly and collectively termed Emerging Chemical Management Issues (ECMIs).

For this document, ECMI is defined as any potential or recognized human health and/or environmental effects concern associated with chemical(s) whose management is not or only partially addressed by existing MEAs. The term ECMI does not have any legal standing, recognition, or implication. Its use is entirely as a collective shorthand.

Since ECMI clearly refers to 'issues', it can include specific chemicals or chemical classes, products and/or wastes containing chemicals of concern, uses, processes, as well as generic human and environmental health effects. There are different ways to classify issues, but all have the problem of overlap because there are often multiple considerations involved, such as multiple sources, sources with multiple releases, and chemicals with multiple effects.

It is well-recognized that, because Developing Countries and CEIT have chemical management regulations and enforcement of variable effectiveness, it is possible that in some instances ECMIs may be of greater prominence or concern in Developing Countries and CEIT than in Developed Countries. On the other hand, ECMI's are often first recognized in Developed Countries, and most of the literature and initial policy interventions will emanate from there.

The immediate goal of the GEF through its present chemicals program is *to promote the sound management of chemicals throughout their life-cycle in ways that lead to the minimization of significant adverse effects on human health and the global environment*. This goal is aligned with other internationally agreed goals and objectives with respect to sustainable management of chemicals, including those of the SAICM.

In light of the above considerations and towards achieving the goal of the GEF chemical management program, this report identifies and evaluates ECMIs in relation to the likely chemical management needs of Developing Countries and CEIT such that additional resources and support from GEF within its mandate will anticipate, prevent, reduce and/or minimize adverse impacts on human health and the environment. As a first screen, this report is not limited to ECMIs currently legible for GEF intervention. The ECMIs identified will be considered and prioritized for further assessment, and to inform the GEF and other agencies and stakeholders for further consideration.

Chapter 2 examines ECMIs in more detail. Chapter 3 assesses the policy and financial mechanisms dealing with ECMIs, and Chapter 4 identifies the criteria used to categorize and prioritize ECMIs. Chapter 5 assesses each identified ECMI in more detail, while Chapter 6 presents the results of the survey undertaken to prioritize ECMIs for Developing Countries and CEIT.

CHAPTER 2

Scoping the Emerging Chemical Management Issues

Scope

Since almost all human activities can be related in one way or another, an exhaustive survey of only one dimension, namely all chemical compounds or classes of compounds, would be impossible. This document will identify and consider major identified Emerging Chemical Management Issues (ECMIs) associated with the production, transport, use and disposal of chemicals that can affect human and environmental health at any stage and that may, can, or should be mitigated through management interventions. In some cases, chemicals will be treated in generic groups although there will be obvious differences between compounds. Analytical procedures, monitoring, production figures, and history will not be addressed.

A number of criteria were used to limit the number of selected ECMIs. In particular, the following issues will not be considered here, but may need (or are getting) specific attention elsewhere:

- Chemicals sufficiently regulated or actively considered by existing and planned MEAs or other international initiatives. Mercury, halogenated flame retardants, perfluorinated compounds, and pesticides for instance, will not be considered here.
- The radiation effects of radio-nuclides will not be considered, except where the elements also have toxic properties other than radiation damage.
- Anthropogenic particulates, gasses, and aerosols that contribute to climate change and ozone depletion will not be considered, except when they are toxic as well.
- Contained solid and liquid wastes will not be considered, except where they are secondary sources of chemicals.
- Well-known effects such as acetylcholine esterase inhibition, membrane ion channel effects, accumulation, skin irritation and others will not receive direct attention, as it is assumed these have mostly been covered by existing regulation. These are however, covered under the ECMI called Mixture effects.
- Immediate effects of military products such as teargas, obscurants (smoke), chemical weapons, etc, will not be considered, nor the explosive and other hazards associated with stored and properly managed unused munitions and other weapons. However, the after-effects and releases from exploded and unexploded munitions and other military equipment use may have transboundary implications and will be addressed. Only conventional munitions will be considered.

Background

The increasingly effective management of deliberate or unintended release or use of chemicals has diminished serious environmental or health consequences such as deaths and biodiversity impacts of chemicals in many parts of the world. This is mostly due to increased awareness and consequential combined action from private, civil society, and government sectors. The instruments for such action include, *inter alia*, regulations, voluntary withdrawal of products, and the application of BAT (Best Available Techniques) and BEP (Best Environmental Practices), on local, regional, and international scales. One example is that due to the almost complete banning of DDT, biodiversity has benefitted in many parts of the world. The negative effects associated with chemicals such as dieldrin and mirex have all but disappeared, showing that effective management is possible.

In general, effective chemical management and enforcement in Developing Countries and CEIT has lagged behind Developed Countries standards (that are also evolving) for a variety of reasons. Throughout production, import, transport, storage, use, and disposal, there are many opportunities or situations where releases and exposure can occur beyond acceptable intended use and design limits through misuse, lack of awareness, and/or accidents.

Increased urbanization and industrialization characterize many Developing Countries and CEIT, and is often associated with poverty and disease. Economic cycles or emergencies can reduce or delay the capacity of governments to implement or manage chemicals that in turn may lead to increased exposures and consequent negative human and environmental impacts. Poor nations and regions may also prefer or have to rely on cheaper (but more dangerous) 'legacy' products or products produced by older technologies that are not manufactured in Developed Countries. The shift of many manufacturing and mining operations to developing countries may partially be attributed to laxer environmental and occupational regulations and/or enforcement thereof. Many processes or practices are cheaper and more polluting than available but initially more expensive BAT and BEP, and these practices and technologies are therefore retained while there are still markets. Contaminated, deliberately mislabeled, or tainted/adulterated products are also more likely to be traded to nations that do not have the enforcement capacity, or to where it is known that product monitoring is not effective. Conversely, however, some multinational corporations operating in Developing Countries and CEIT may maintain higher than required operating standards as part of their occupational, social, and environmental responsibilities.

Poverty and lack of development can exacerbate exposure to contaminated products, wastes, and environmental residues in many countries, not only in Developing Countries and CEIT. Polluted water, air, food, and compromised ecosystems has impacts on human health and development potential. Often people live close to sources and waste dumps, rely on untreated water, and use open burning for heating and cooking. These sources also contaminate the environment with knock-on effects in wildlife and ecology.

Emerging chemicals and emerging concerns

The term 'emerging chemicals' more accurately refers to the emerging awareness and scientific knowledge of the real and potential impacts of existing and newer chemicals, and not strictly to 'new' chemicals per se. There is therefore a historic component to this, as, for instance, the Stockholm Convention (SC) had as a first target, twelve well-known chemicals. After the adoption of the SC, additional chemicals were considered, some 'old', such as polybrominated biphenyls (PBBs) and lindane, but also 'newer' chemicals such as brominated flame retardants and perfluorinated compounds. These are now part of the SC prevue, and additional chemicals are under consideration. Most of the 'legacy' compounds seem to have been adequately addressed (at least in Developed Countries), and the chemicals currently under consideration can be considered 'emerging' although some have been in production and use for decades, such as the chlorinated paraffins. There remain some unintended (well-known and therefore 'old') chemicals, such as the class of poly-aromatic hydrocarbons (PAHs), that still needs more attention, but does not seem to have a comprehensive international management mechanism.

Another interpretation of 'emerging chemicals' is that through more research, more effects and impacts of both 'old and new' chemicals are found. Known impacts are now not only restricted to cancer and mortality anymore, but concerns more subtle effects, as will be expanded on below. With improved analytical instrumentation, biological testing, and public concern as to the possible impacts chemicals may have on their health and their environment, these 'emerging concerns' of both older and newer chemicals have garnered much attention from scientists, policy makers, news media, industry and civil society. Improved detection limits and expanding research capacity has seen publication of reports and scientific articles on older chemicals that did not get much attention previously, and the newer chemicals. The simple fact of an increased demand for production and consumption of chemical based products by more prosperous peoples, more numerous peoples, and combinations thereof all over the world, means that more chemicals end up in the environment – both 'old and new'.

Although the research capacity into these issues are mainly located in Developed Countries with an often better informed public and civil society, awareness of these issues are also increasing in Developing Countries and CEIT, especially following recent incidents of adulterated products, such as food and medicines, dumping of wastes, industrial accidents, and effects on wildlife such as on the vultures in India and predators in eastern Africa. Shipment of hazardous waste (especially electronic waste) to developing countries, and the dumping of wastes in countries and territories with less or no effective government, has also been in the news, indicating impacts in regions far removed from where the products were originally used as well as a lack of enforcement and responsibility of some parties involved.

The environmental behavior of chemicals is now much better understood. Long-range transport (LRT) via air, water or migratory biota, chemical-physical interactions, partition coefficients, and modeling are just some of the ways that chemicals can be present in areas where they were not produced or used. LRT, combined with an increase in trade in chemicals and products, affects a redistribution of compounds over the globe and has implications for human and ecosystem health.

Another source generating new concerns is the increasing number of ways to investigate biological effects. Biomarker research has expanded tremendously as the phenomenal increase in biological, biochemical and physiological knowledge has added opportunities to investigate effects of chemicals. Biomarkers such as acetylcholine esterase inhibition and ion channel activity modulation are well known as they represented target effects of chemicals such as pesticides. The thinning of bird eggshells can also be considered as a classical effect of chemical pollution, but it still attracts attention as a relatively easy effects end-point. 'Newer' biomarkers or existing biomarkers now better understood are, however, increasingly identifying concerns on non-target systems, often by effects not immediately linked to the intended effects or purpose of a specific chemical.

A good example of such a 'new' concern is the modification of endocrine systems through endocrine disrupting chemicals (EDCs). Although reproduction has been an established end-point in the testing regimes of chemicals for a long time now, effects that are more subtle and sometimes only seen at low concentrations or doses and over longer terms, is a major focus of current research in especially animals in the laboratory and field, but also, more alarmingly, from human studies. EDC have attracted much public and regulatory attention, with tributyltin (TBT) as arguably the best example. The current discussion associated with compounds such as nonylphenol and bisphenol-A is reminiscent of the DDT, ozone depletion, and tobacco smoking debates. Since compounds from many different chemical classes seem to be involved, endocrine disruption is handled as an ECMI of its own in this document. It is anticipated that this ECMI will attract even more attention in the future

Carcinogenicity and neurotoxicity of chemicals is a great concern and will remain one of the major screening criteria. Other biological effects include immunosuppression, genotoxicity, oxidative stress, retinoid transport, apoptosis, and histopathology, among a host of biomarkers. It can also be anticipated that more biomarkers will be discovered, especially through toxicogenomics, metabolomics and proteonomics. There is also a trend to employ multiple biomarkers in studies, since it is becoming increasingly clear that the same biological systems from different taxa (or strains, gender or age groups) do not respond in the same way to the same chemicals. Interactions between pathogens and chemical stressors have also seen research efforts and will likely pose some significant future challenges. It is not improbable that a 'new' chemical might interact with an emerging pathogen creating a potentially serious effects scenario. Organisms genetically modified to interact with specific compounds, or that produce chemicals, may also be seen in a similar light. Investigations of effects with long lag periods between exposure to chemicals and expression of effects, even across generations, have also seen expanded effort.

On the organismal level, a body of literature is emerging showing potentially serious impacts on behavior such as nest attentiveness in birds and valve closing in mollusks. Since many chemicals are produced to modify behavior in humans, these may also have effects on non-target organisms, including humans themselves. Effects of chemicals on growth, especially during sensitive life stages, are also getting more attention in literature.

New products have been mentioned a number of times, but a class of potential or real pollutants are nanoparticles and materials. Although not strictly a chemical, their small size, reactivity, physical properties, uses and sources, brings it in the realm of an ECMI and will get attention here. In the same vein, new chemicals or classes of chemicals may not fit established screening criteria or regulatory mechanisms, or its uses may lead to as yet unrecognized or poorly understood exposures, transformations, and health and environmental effects. These new types of chemicals or chemical-like products will remain a challenge as, from experience and past successes, it is clear that negative impacts should rather be prevented than mitigated.

One serious issue that is getting increasing attention is that of effects due to exposures to multiple chemicals. Regulations normally target single chemicals or classes of chemicals, but not combinations of different chemicals which is the norm. The toxicity of mixtures is generating an increasing body of literature and theory, but it seems, a clear view of this issue is still to be synthesized. However, it is probably one of the most important ECMIs, given the increasingly complex 'anthropogenic mediated chemical environment'. Its development needs to be closely tracked as it may have far-reaching implications for current and new chemicals management.

On the ecological level, concerns about species, ecosystems, and ecosystem functioning are scattered throughout the literature. These could be the result of cascading effects affecting key components or functions in an ecosystem that could include biological and /or physical aspects such as nutrient and energy cycling and the integrity of biological communities. Acidification and salinization of soils and waters are immense problems in many countries and could have transboundary impacts. Migration of animals also brings them into contact with different combinations of chemical pollutants in various parts of their migratory range.

Emerging chemical concerns, arguably, may also include aspects that are more difficult to anticipate, quantify, or to attribute to any clear management responsibility or cause. These are listed here for completeness and awareness.

- Anthropogenic and climate interactions may disturb releases of methane and possibly other gasses through destabilization of methane hydrates and melting of the Arctic permafrost.
- Releases of chemicals from melting ice, permafrost, or sediments may lead to release surges of decades of captured chemicals.
- Pollutants presumed safely captured in 'sinks' may be released again through changing climate, droughts, floods, storms, or anthropogenic disturbance.
- Algal blooms or other 'mega biodiversity disturbances' may lead to releases of biotoxins.

Characteristics of the Emerging Chemicals Management Issues

Emerging Chemical Management Issues are therefore a combination of the following elements:

- Newer and well-known chemicals receiving attention due to strengthened or new regulations and MEAs
- Well-known chemicals now receiving closer scrutiny after 'legacy' compounds became more regulated
- Increased awareness of effects of chemicals and mixtures of chemicals at sub-lethal levels due to scientific advances
- Increased awareness of how LRT and trade distribute chemicals globally
- Increased awareness of the real and/or potential compromise of human and environmental health globally due to pollution and exposure
- Realization of the need for strengthened chemicals management in Developing Countries and CEIT
- Based on experiences, problems and intervention successes, a vision to minimize current negative effects and to anticipate and, where possible, prevent future negative impacts.

Crosscutting issues

Chemicals management and environmental pollution cannot be seen in isolation. Some of the crosscutting issues have been mentioned above and a non-exhaustive list of these are presented below. It should be noted that these issues are not exclusive and have complex interlinkages.

- Poverty
  - Vulnerable populations
  - Urbanization
  - Lack of awareness of chemical issues
  - Economic cycles (both positive and negative)
  - Legacy waste sites and wastes not covered by current MEAs
- Lack of regulation and enforcement
  - Dumping
  - Shift of production of chemicals to Developing Countries and CEIT
  - Non-regulated uses
  - Build-up of new dumps of products, product wastes and obsolete chemicals
  - Occupational health
- Accidents and spillages
- Illegal manufacture, transport, trade and uses
  - Adulterated products
  - Mislabeling
  - Smuggling
- Climate change
  - A whole host of environmental issues and interlinkages are involved but is poorly understood. This is an issue that needs much scrutiny, as many Developing Countries and CEIT are or will be affected (IFCS, 2008a; 2008b).
- Biodiversity
  - Endangered biota
  - Migratory animals
  - Habitat destruction
  - Impaired reproduction
  - Invasions and alien species
  - Problem animal control
- Compromised supporting environments, biodiversity and ecosystems
  - Eutrophication
  - Acidification, salinisation,
  - Freshwater and marine pollution
- Conflict and war situations
  - Refugees
  - Weapons and other chemical use and wastes
  - Damaged or destroyed infrastructure and institutional capacity
- Disease(s)

CHAPTER 3

Policy and financial mechanisms dealing with Emerging Chemical Management Issues

Background

Emerging chemical management issues (ECMIs) represent a great challenge not only to industry, but also to government and regulators in Developing Countries and CEIT. This is mainly because the backlogs and delays experienced in addressing the existing and well-recognized chemical issues (such as the "twelve" and additional POPs in the SC), and the lack of adequate capacity.

Up to now, chemicals that are persistent, bioaccumulative, and toxic (PBT chemicals), have been on the top of the international agenda through the implementation of the Stockholm, Basel, and Rotterdam Conventions. Research has shown that chemicals in addition to the 22 currently regulated by the SC have similar properties; in fact, a recent publication from Muir and Howard (2006) revealed a list of more than 150 chemicals that share the properties of PBTs and POPs. Strempel et al. (in press) also identified a large number of chemicals that may be of concern to human health and the environment. Some of these chemicals are widely used in Developing Countries and CEIT.

A number of MEAs regarding chemicals are in force that needs to be taken into account. Examples are:

- The Stockholm Convention is a major achievement that complemented a number of other chemical-related global or regional conventions, agreements, and action plans, primarily the Basel "Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal," and the Rotterdam "Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade,"
- Global concerns or treaties are often translated into regional specialized agreements, action plans, and declarations. Examples are the Bamako "Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes Within Africa", and the Waigani "Convention to Ban the Importation into Forum Island Countries of Hazardous and Radioactive Wastes and to Control the Transboundary Movement and Management of Hazardous Wastes Within the South Pacific Region".
- The recent Bahia "Declaration on Chemical Safety" of the Intergovernmental Forum on Chemical Safety (IFCS) also reaffirms government's commitment to the promotion of sound chemical management. Even though these treaties and conventions do not address ECMIs specifically or only partially, there may be options to include additional concerns such as ECMIs.
- MERCOSUR, a group of countries from the southern cone of the Americas, have decided to promote an action plan on chemicals based on priority substances where mercury and leaded gasoline, pesticides, waste, contaminated sites, and human health are on the agenda.

The inclusion of newer ECMIs in these MEAS is rather limited, in part because the knowledge of these issues is recent, however there is an opportunity to raise these issues, but due to the multiplicity of factors implied (see the previous chapters), a careful prioritization should be performed in order to prevent the inclusions of chemicals in black of grey list if a sound scientific base is not existing.

In 2010, the Executive Director of UNEP, in the context of emerging policy issued, a document on "Financing the chemicals and waste agenda (UNEP, 2010), indicating a series of issues that needs to be addressed. In this far-reaching assessment, a number of policy options have been developed. Briefly they are:

- the need for clear and coherent international leadership,
- raising political priorities,
- strengthening policy and regulatory frameworks,
- cooperation and synergies between MEAs,
- synergy in delivery mechanisms, and a
- cradle to grave approach.

Innovative approaches included:

- green economy,
- public private partnerships, and
- economic instruments to internalize social and environmental costs.

Radically, it suggested that:

- GEF includes a safe chemicals management focal area or strengthen the POPs focal area,
- expand the mandate of the Multilateral Fund,
- create a multi-donor Trust Fund,
- use SAICM as the reference policy framework, and
- use existing stakeholder mechanisms to leverage the impact of individual funding sources.

Recent developments

Since 2006, the Strategic Approach for International Chemicals Management (SAICM) is playing a major role and is potentially a pathway to include ECMIs in the international agenda, since it concentrates in chemicals not regulated by MEAs.

During the recent International Conference on Chemicals Management held in Geneva in May 2009 (SAICM, 2009), four policy issues were raised by the participants as of relevance for international action. One of the resolutions of this conference addressed the following issues:

- Lead in paint
- Chemicals of concern in products
- Hazardous substances within the life cycle of electrical and electronic products (E-waste)
- Nanotechnologies and manufactured nanomaterials

Additional issues considered were perfluorinated chemicals and their transition to safer alternatives, and endocrine disruption (SAICM, 2012).

The following initiatives were taken:

- In the case of leaded paints, actions were agreed to promote the phase out of such products by first identifying partnerships with donors for supporting a global action. This action will be led by WHO and UNEP.
- The issue of chemicals in products will also be addressed, in this case, a steering group will be established by UNEP, and a methodological approach will be developed for the analysis of existing information systems.
- Another policy issue considered was the hazardous substances within the life cycle of electrical and electronic products; in this case, UNIDO will be the responsible agency working with the Basel Convention Secretariat. One interesting point is that the life cycle approach was adopted to undertake such action.
- In the case of nanotechnologies and nanomaterials, the chosen action was to introduce the issue to Developing Countries and CEIT by raising awareness through the development of informative workshops. OECD and UNITAR will be the executing agencies for this issue.
- Perfluorinated chemicals were also considered of high relevance regarding the issue of transition to safer alternatives. In relationship to the alternatives, a potential issue of concern is the recycling of chemicals of emerging concern into other products. Given the absence of regulations, it is not clear if acceptable uses for recycling are allowed. This is a topic on the international agenda, and the POPs Review Committee of the Stockholm Convention is developing some recommendations on that (See POPRC 5 documents).
- The OECD is considering the promotion of stewardship programs and regulatory approaches at national and international levels for these chemicals. SAICM is open to new policy issues and a mechanism is envisaged allowing stakeholders to set up emerging issues for the next conference.

Specific initiatives for addressing these issues are being put together by various role players, and there are opportunities in areas such as:

- pesticides management,
- capacity building regarding legislative and regulatory framework and enforcement,
- adaptation regarding alternative chemicals,
- protected areas,
- contaminated sites,
- heavy metals,
- waste minimization and disposal,
- information exchange, and
- illegal traffic of chemicals and wastes.

Gaps observed

According to the Society of Environmental Toxicology and Chemistry (SETAC, 2008), developing countries face several problems with respect to chemicals management. Regional, ecological (climate), socioeconomic, and political differences ensure a wide range of environmental quality problems. Levels of pollution that exist in emerging economies are not necessarily equivalent to concerns identified in industrialized economies. Chemical use and exposure patterns in Developed Countries may differ significantly in Developed Countries and CEIT situations. Applicability of existing datasets (e.g., fish toxicology) to different regions may be limited because of differences in the functioning of ecosystems (SETAC, 2008). There is some discussion about the use of word 'emerging', since even 'old' chemicals in the developed world could be of emerging concern in Developing Countries and CEIT.

SETAC identified two major issues; one relates to regional differences regarding chemical uses and management and the second to the life cycle approach for chemicals.

- Most of the problems detected relates to the lack of capacities in Developing Countries and CEIT to identify and address problems raised by chemicals due to the lack of funds and knowledge on the issues. Some of the chemicals mentioned by SETAC are pesticides (problems with obsolete stocks), alternatives for pest and disease vector control, e-waste, disinfection by-products, pharmaceuticals, halogenated phenols, less-studied PBT chemicals, polybrominated diphenyl ethers (PBDEs), perfluorinated compounds (PFCs), and nanomaterials. Other identified issues are food and toy safety, chemical and biological problems related to mining (e.g. mercury), potable water issues (water quality, e.g., arsenic), chemical problems from open burning and the handling of combustion products (ashes, coal). Many of these chemicals may already be 'traditional' or well-understood pollutants in the developed world, but their recognition in Developing Countries and CEIT is now increasing.

- Life Cycle Analysis (LCA) is a management technique for addressing chemicals of emerging concern, as many of emerging chemicals are products or incorporated in products. LCA is based on the analysis of products that can be used in the evaluation of products and their alternatives. Within the categories of chemicals of emerging concern are pharmaceutical and personal care products (PPCPs) that occupy an important position. In this case, developing countries usually import the active ingredients and formulate the products locally. Also, several companies are moving their manufacturing to Developing Countries and CEIT. Moreover, Developing Countries and CEIT often do not have adequate sewage or waste water treatment facilities with the consequence of increasing emissions of chemicals of emerging concern into the environment. An important issue in particular for Developing Countries and CEIT is to promote educational and labeling initiatives and, importantly, the adequate support for research, development, as well as technical support for safer chemical management.

It must be noted, however, that chemicals not included in the conventions maybe or are of emerging concern for Developing Countries and CEIT, as may be implied from the lack of data even for the 'legacy' POPs in the latest monitoring reports from Latin America, Asia, and Africa (Regional Monitoring Reports of the Stockholm Convention, 2009). SAICM, through its Quick Start Programme, is seen as one of the potential avenues for cooperation and financial support for ECMIs, both at regional and global level. One of the gaps in GEF support is in that normally only chemicals already included in the conventions are subject to support. This situation may change, however, in the near future. When this happens, mechanisms to address ECMIs will become available. From a Developing Countries and CEIT need, such mechanisms would, *inter alia;*

- obtain information on the properties and uses of chemicals,
- ensure information is transmitted to users of these chemicals.
- where necessary propose measures on certain chemicals or uses, and
- identify alternatives for problem substances.

CHAPTER 4

Identification of and criteria for categorization and prioritization of Emerging Chemical Management Issues

The drafting group, with the assistance of STAP and GEF, identified a preliminary list of ECMIs based on numerous policy and guidance documents, combined knowledge, and active screening of recent literature. The ECMI screening process included some of the following considerations:

- It must have an identifiable anthropogenic cause
- It must have identifiable contaminants, even if not all are known or fully characterized
- The contaminants must have toxic or potential toxic implications
- Trans-boundary implications (including trade) must be shown, implied, or suspected
- The availability of mitigation options

The following journals were actively scanned for ECMIs, looking at issues between 2008 and 2009.

- Chemosphere
- Environmental pollution
- Ecotoxicology
- Environmental science and technology
- Environmental health perspectives
- Environmental toxicology and chemistry
- Archives of environmental contamination and toxicology
- Environmental geochemistry and health
- Marine pollution bulletin
- Nature
- Science
- Integrated environmental assessment and management

In addition, other journals, policy papers and other documents from a wide variety of national and international sources, including NGO publications, were scanned for concerns. In the course of their duties, the authors also attend scientific conferences, where emerging issues were scanned from the presentations.

A meeting was held to determine the report format and paring down or consolidating the number of ECMIs to consider. In most cases, when an ECMI was not considered on its own, it was incorporated with a closely related ECMI (e.g. cyanide in gold mining was added to mining) so as not to lose the issue.

Four types of ECMIs were identified:

- Compound/class based,
- Product based,
- Effect based, and
- Process based

For many of the ECMIs there are overlaps between the four types identified. This classification also does not imply any hierarchy of greater or lesser importance.

Since the exercise was to identify 'emerging' concerns as described in the previous chapter, not all ECMIs would be comparable regarding scope, existing knowledge, or basis for being identified as an ECMI. Again, it must be stressed that being listed as an ECMI does not have any legal standing, recognition, or implication. Its use is entirely as collective shorthand solely for the purpose of this report.

The ECMIs were divided between the three drafters according to best fit against experience or interest, and a report format was decided. The report format was according to the DPSIR framework (EEA 1997) (Drivers, Pressures, State, Impact, and Response) and adapted to headings appropriate to the purpose of this report:

- Releases,
- Pollution,
- Exposure and uptake,
- Effects,
- Trans-boundary issues,
- Cross-cutting issues,
- Management options, and
- Intervention need.

Development of ECMI criteria

To compare the identified ECMIs and to enable priority setting, a number of criteria were identified and presented in table form below. The authors of this paper used the following criteria to carry out their own ranking exercise and assessment of the ECMIs identified (the results of which are in Chapter 5 of this report). Because the authors developed the ECMI descriptions in Chapter 5, they developed a very good overview of all ECMIs and were able to compare the ECMIs on an equal basis, based on the knowledge gained from the overview, as well regional knowledge.

To characterize and compare the ECMIs, two groups of criteria were identified by the authors: ECMI Concern Criteria, and ECMI Descriptive Criteria. The ECMI Concern Criteria consisted of eight items for consideration, aimed at describing concern of that ECMI from eight perspectives. All criteria were given four scoring levels, with scores increasing from left to right. The level best applicable is ticked with an X to the right of that level. The ECMI Concern Criteria were designed and arranged such that the different levels of descriptors can be summed as an "ECMI Concern Profile". The profile therefore will have four values, the sum of the number of ticks in each column. In the example above, the ECMI Concern Profile reads 1, 2, 4, 1. The interpretation of this profile would be that and ECMI with higher values to the right (e.g. 0, 2, 3, 3) would be of relatively higher concern, based on current levels of knowledge, compared with a concern profile with higher values to the left (e.g. 3, 3, 2, 0).

The ECMI Descriptive Criteria has three descriptive items, permitting a more objective view of the current state of the science, management capacity, and global/regional cooperation to address problems associated with that specific ECMI. The descriptive criteria cannot be summed as they do not have commonality, but they are aimed at assisting in interpreting the ECMIs and ECMI Concern Profiles. The individual concern criteria, as well as the summation, should be read in conjunction with the descriptive criteria when considering individual ECMIs or comparing different ECMIs. In the example above, the descriptive criterion for Scientific knowledge from Developing Countries and CEIT was deemed 'Poor'. When the Scientific knowledge score is compared with the ECMI Concern Profile (1, 2, 4, 1) the scientific confidence on which the scoring for the ECMI Concern Profile criteria is based would likely be on science from Developed Countries. There were 'Some' Management options available. There are no known MEAs that includes this ECMI, and therefore multilateral support to address this ECMI is lacking.

An ECMI Concern Profile towards the right (e.g. 1, 2, 4, 1) should therefore be considered of higher relative concern than an ECMI Concern Profile with higher values towards the left (e.g. 3, 3, 2, 0). The scientific foundation for considering multilateral aid to implement or adapt available Management options should receive preference to an ECMI with an ECMI Concern Profile with higher values to the right. (Further considerations about scoring and ranking are provided in Chapters 6 and 7.)

	ECMI Concern Criteria	Example ECMI							
1	Concern to DC&CEIT	Unknown		Low		Intermediate	X	High	
2	Geographical scale of impact	Unknown		Local		Regional		Global	X
3	Trans-boundary issues	Unknown		Low	X	Intermediate		High	
4	Impact on ecosystems	Unknown		Low		Intermediate	X	High	
5	Impact on human health	Unknown		Low		Intermediate	X	High	
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown		Low	X	Intermediate		High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**1**		**2**		**4**		**1**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor	X	Intermediate		High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No	X	Partially		Completely	

Each criterion was scored by the authors. The scoring was based on the combined overview of each ECMI provided in Chapter 5 as well as their expert judgment and experience from the regions. Since the authors were au fait with all ECMIs through the process of putting the report together, this presents a balanced approach. Any score can be updated as and when more information becomes available. A summary of the 22 ECMI Concern Profiles is presented in Table 6.1.

The same sets of criteria were also used to develop a survey of experts from Developing Countries and CEIT. The results of this survey are also presented in Chapter 6.

The ECMI Concern Criteria

1. **Concern to Developing Countries and CEIT:** As identified before, most of the information regarding ECMIs comes from Developed Countries. Judgment was made, based on the insight and expert knowledge, at what level the specific issue is or might be a concern to Developing Countries and CEIT. Considerations here also included whether appropriate and effective regulatory mechanisms were present.
2. **Geographical scale of impact:** ECMIs with clearly current isolated concerns scored 'Local'. This criterion is semi-independent of the trans-boundary criterion, as potentially, an ECMI shared by small states may cover only a small geographic region. Its impact might be significant even when geographically restricted, and the text should be consulted for clarification. Small Island states were not considered as 'small', as they often cover large territories.
3. **Trans-boundary issues:** In line with the GEF mandate, ECMIs that have clear or potential impact across at least one national border were included. Since there are regions with small states grouped together, very few concerns were eliminated on this criterion. However, some ECMIs had no information on this issue, and were included based on potential cross-boundary concerns, but rated as unknown.
4. **Impact on ecosystems:** This criterion included all concerns relating to the whole range of issues between genetic implications to ecosystem functioning. Consideration for scoring was much the same as for human health.
5. **Impact on human health:** Impacts on humans other than health were not considered here. Human health was one of the major issues that became apparent when considering ECMIs. Again, proven or potential impact was considered.
6. **Climate change impacts:** The production, use, disposal, environmental and health impacts and related aspects may either have an effect on climate change, or be affected by climate change. For many of the ECMIs, very little is known about this criterion.
7. **Economic and social issues:** The production, use, effects and management of a particular ECMI may also affect economic and social issues, or be affected by it.
8. **Intervention priority:** Based on a number of considerations including human health and environmental impacts, a judgment was made on the urgency for appropriate and effective intervention. ECMIs that scored low in the previous criteria normally would score lower for this criterion as well. However, the score may need adjustment when new information becomes available.

Summation of the ECMI Concern Criteria scores indicates relative global concern and should be used for ranking only; not for absolute impact, hazard, or risk. Care should be taken with interpreting the concern profiles, as an ECMI with a left-handed profile (e.g. 2, 5, 1, 0) may very well have a much higher regional concern than other ECMIs in the same region, and the ECMI with a regionally higher concern should receive priority attention over one with a higher ranked global priority. Interpretation and closer scrutiny is therefore required on a regional basis. Interpretation should also take into account the many commonalities and interactions between ECMIs.

The ECMI Descriptive Criteria

9. **Scientific knowledge:** As mentioned previously, most of the ECMIs will have initially been identified and described in Developed Countries. The source of much of the relevant scientific literature will also be from these countries. For some ECMIs there will also be scientific information from Developing Countries and CEIT. Based on experience however, most if not all the scientific knowledge of ECMIs in Developed Countries will also have relevance to Developing Countries and CEIT. Translating the scientific knowledge from Developed Country situations to Developing Countries and CEIT situations for this report is based on expert judgment of the conditions in Developing Countries and CEIT. Only in isolated cases, will there be a likelihood of scoring scientific knowledge of an ECMI as 'None'.

10. **Management options available:** An analysis of available management options for each ECMI is beyond the scope of this study, which is aimed primarily at selection and prioritization of ECMIs. Since many management options are generic to most ECMIs, these are not dealt with in detail, but only treated cursory with each ECMI.

11. **Addressed by MEAs:** If a MEA is known to address an ECMI completely for Developing Countries and CEIT, it will not be represented in this report. ECMIs in MEAs that only over some Developing Countries and CEIT, or ECMIs only partially addressed by any MEA will score 'Partially'.

Given the intricate and interlinked nature of ECMIs, these criteria are not exclusive and there will be commonalities and possibly some gaps. Commonalities and gaps are identified in text. Expert judgment was applied for scoring. When no clear decision could be made for a particular score (say between 'Low' and 'Intermediate'), caution was applied. Up- or down grading can always be applied when more information becomes available. Although each ECMI is different in scope and scale, direct comparisons between ECMIs are indicative only – the text and newer information should always be consulted when doing this. When comparing ECMIs, it should also be kept in mind that many of them have crosscutting issues. Many ECMIs are also related to greater or lesser extent; therefore, intervention on one or more ECMIs may have direct or indirect impacts on related ECMIs.

The drafters scored each ECMI according to their combined insights. This is presented in table format together with the text of each ECMI, in this Chapter. The scores are summarized in Chapter 6. The scores by the drafters represent an assessment of the drafters as a check on the prioritization process by the respondents. The drafters, having spent much time on each ECMI, have developed a balanced overview of all the ECMIs, while the respondents required a couple of hours to complete the questionnaire. The respondents however, are more *au fait* with their respective regions.

Prioritization of ECMIs

During the final drafting, an electronic survey was undertaken by SETAC (Society of Toxicology and Environmental Chemistry. SETAC is a non-profit, worldwide professional society comprised of some 6,000 individual scientists and environmental professionals from government, academia and business engaged in:

- the study, analysis, and solution of environmental problems
- the management and regulation of natural resources
- environmental education
- research and development

SETAC's mission is to support the development of principles and practices for protection, enhancement and management of sustainable environmental quality and ecosystem integrity. SETAC promotes the advancement and application of scientific research related to contaminants and other stressors in the environment, education in the environmental sciences, and the use of science in environmental policy and decision-making.

An electronic survey was undertaken by SETAC of its membership consisting of scientists from government, academia, and business living in or actively working in developing countries and CEIT. SETAC also engaged other organizations and networks such as SAICM focal points from governments and NGOs, the Pan African Chemistry Network and the International Foundation for Science. SETAC members (including those from Developing countries and CEIT) interact and network in a global commons by:

- Attending SETAC conferences conducted in all major geographic areas
- Participating in global advisory groups (currently twelve)
- Newsletters and webinars

SETAC members are thus aware of the latest scientific developments and pollution issues from across the globe. Significant bias of any kind was therefore deemed not have played a role. This shows the advantage of using the broad membership base of an international scientific organization that holds regional and global conferences including in Developing Countries and CEIT, and have a membership from all regions.

The survey was disseminated electronically using Survey Monkey (www.surveymonkey.com) by SETAC to more than 700 addressees; 194 responses were received, representing six continents and regions. Individuals who only filled out demographic information but were unwilling or unable to complete any of the survey questions were removed from the data set. Respondents were asked to identify the region for which they had the most expertise, which in turn would provide a proportion of the analytical basis for this report. Of the 135 verified respondents (19% of the initial sample), the survey results indicate that academicians located throughout the regions were the greatest sector to respond at 50%. Governments across the regions yielded 25% of the responses. Four NGO members accounted for 3.1% of the responses and two individual respondents were private consultants (1.6%). One individual (0.8%) was with an Intergovernmental Organization. From Central and South America, 44 (33%) responses were received, 39 (29%) from Africa, 27 (20%) from Asia, 20 (15%) from Eastern Europe, and 4 (3%) from Oceania that included one each from New Zeeland and Australia.

A paragraph-length summary, consisting of basic information such as production and use, releases, exposure routes, and impacts on human health and the environment was used as introduction for each ECMI. The summary descriptions were reviewed by 89% of the respondents. The questionnaire used the same ECMI Concern Criteria and ECMI Descriptive Criteria for scoring as described above. With respect to the three ECMI Descriptive Criteria, 50 respondents entered assessments for Scientific knowledge. This was enough for an overall ranking, but not for regional breakdown. Only few respondents scored the remaining ECMI Descriptive Criteria; therefore, the scoring by the authors was used to describe state of the science, management options and global/ international mechanisms to deal with the ECMI issues. The respondents were also asked for open-ended remarks for each ECMI as pertaining to their region. In Chapter 5, the ECMIs are described and the state of science of each ECMI given, along with ECMI analyses as done by the lead authors, including the ECMI Descriptive Criteria Analyses. Though the surveyed scientists in the field were not uniform in using the descriptive criteria, the aforementioned open-ended remarks are still highlighted immediately after the lead author ECMI analyses for each ECMI. In Chapter 6, the results and discussion focus more on the ECMI Concern Criteria based survey results, as well as the resultant relative rankings.

Ranking process

The raw data was examined for anomalies. Care was taken to remove instances where respondents were responding for multiple regions. The physical location of the respondent was used to assign him finally to a particular regional category. It was also noted that in some cases, respondents answered some but not all of the questions posed. The eight ECMI Concern Criteria were scored as Unknown / Low / Intermediate / High by the respondents were quantified as 0 / 0.25 / 0.5 / 1, respectively. These were then summed for each question, for each ECMI, for each region. The resultant values were then summed and again ranked for each ECMI as the Aggregate concern. Other forms of normalizing data[2] were also attempted, but all resulted in similar results on rankings, indicating the robustness of the methods used to deal with uneven size of regional responses and data sets. Ranking per concern criterion and for Aggregate concern was then carried out using MS Excel's ranking function. For the combined (all regions) ranking, the regional values were divided by the number of respondents for each region, summed, and then ranked. Each region therefore had one vote. Other divisors were considered such as number of people per region, GDP, land surface area, etc, but the results would need further interpretation.

Early on, it became apparent that Oceania had a ranking pattern different from the other regions; the global rankings were therefore calculated with and without Oceania. The results are presented in Tables 6.3 - 6.9 in Chapter 6.

A similar treatment was done for Scientific confidence, but only on an overall scale as fewer respondents completed this section. The results are shown in Table 6.10.

2 For example, normalizing the data score per region by dividing by the maxima of the scores given for the ECMIs within any one region, such that the larger scores that invariably arise as a result of there being more respondents from a region are nullified through expression of scores as a proportion of 1.

CHAPTER 5

Current Emerging Chemical Management Issues

This section consists of the ECMI literature-based summaries and assessments done by the three primary authors (Bouwman, Wong and Barra), using the aforementioned ECMI and Descriptive criteria. The ECMI descriptive information was used as accompanying material in the survey. It must be noted that there is an enormous literature available for each ECMI. The purpose of this report was not to compile a complete review of each ECMI, but to supply enough motivation and description for its validity as ECMI. Inevitably, there will be sources of information not referenced, and the drafters apologize for any inadvertently left out. Any further steps to be taken on specific ECMIs would require a much more comprehensive and targeted compilation, review, and assessment of information to derive intervention guidance.

In the subsections "Selected comments from respondents", one will observe heavy use of dashes (- - -) and omitted text, which might reveal governments of various sovereign nations, and/or ministries or organisations therein. These omissions were done to prevent any national offense or embarrassment, as well as to protect the identities of the survey respondents, and prevent any reprisals for expression of honest opinions on the current status and management issues associated with the various ECMI 's identified.

COMPOUND/CLASS BASED

Polycyclic Aromatic Hydrocarbons (PAHs)

Description

PAHs comprise of several benzene rings attached with different functional groups such as $-NO_2$, $-OH$ and $-NH_2$. PAHs in the environment come from either petroleum hydrocarbon contamination or incomplete combustion of organic materials (such as wood, coal, crude oil and its refined products) and may come from both sources. PAHs are lipophilic, can accumulate in living organisms, and are harmful to human health via food chains, with mutagenic, malformation and carcinogenic potential (Kennish, 1984; Zhang and Tao, 2008). The total number of different PAHs in the environment consists of perhaps more than one thousand.

Reasons for Developing Countries and CEIT concern

Although PAHs have long been recognized as a serious environmental and health problem, the continued attention it receives globally, an increasing body of evidence as to its impacts, and a lack of global action, qualifies this compound class as an ECMI.

Releases

The total global anthropogenic releases of 16 US EPA-listed PAHs to the atmosphere is estimated at 520 000 tons in 2004 (Zhang and Tao, 2009). Relative contributions were from; biofuel (56.7%), wildfires (17%), consumer product uses (6.9%), traffic oil combustion (4.8%), domestic coal combustion (3.7%), coke production (3.6%), petroleum refining (2.4%), waste incineration (1.9%), electricity generation (1.4%), and remaining activities (1.5%). Major source countries were China (114 000 tons), India (90 000 tons) and USA (32 000 tons), although the source types differed considerably. The atmospheric releases of PAHs were positively correlated with gross domestic product and negatively correlated with mean income (Zhang and Tao, 2009). Non-anthropogenic sources such as volcanic action (Christensen and Arora, 2007), and releases other than to the atmosphere (such as oil spillages), are possible.

Pollution

PAHs are released to the environment from two main processes: pyrogenic and petrogenic. Pyrogenic sources include almost all combustion of organic materials with the release of PAHs, mainly to air. Petrogenic processes involve the release of PAHs from, oil, coal, tar or other hydrocarbon materials to the environment.

Petroleum hydrocarbon usage on a global scale contributes towards global warming due to the increasing carbon dioxide emitted (IPCC, 2007). There is also an overall increase in marine transportation in the Arctic, which could increase PAH contamination of marine waters (Northern Research Forum, 2009). Urban transportation is also associated with combustion-related emissions of PAHs (rapid urbanization and increase in private vehicles fleets all over the developing world). Furthermore, the continued use of biomass as a major source of fuel in poor communities also contributes to the release of PAHs (Bhargava et al., 2004).

Regional example: Petroleum hydrocarbon contamination is the most common organic pollution found in harbors and coastal waters in the world. Hong Kong is one of the most important international shipping hubs in the South China Sea, with widespread contamination by petroleum hydrocarbons in coastal sediment and water. The highest total PAH concentration measured was 1996 μg/g (dry mass) in the sediment collected from Kowloon Bay in Victoria Harbour (Hong Kong), due to industrial wastewater and shipping petroleum wastewater discharges (SCPMEU BOSP, 1985; Zheng and Richardson, 1999).

Electronic waste recycling, using primitive technologies such as open burning to recover metals from cable wires and circuit boards, release toxic substances including PAHs. PAH concentrations as high as 3206 μg/g (dry mass) were detected in the burnt residues at an open burning site in PR China (Leung et al., 2006; Yu et al., 2006). These residues then find their way into the environment.

Exposure and uptake

Humans are exposed to PAHs via food, drinking water, and air. PAHs also exist in the water column with two-thirds as particles and one-third in the dissolved phase. The dissolved phase is not always removed when water goes through waterworks and therefore enters the drinking water system. Many foods contain PAHs, especially burnt and roasted food. Therefore, humans will take up PAHs via consumption of food and drinking water.

Countries such as China and India that rely on high-ash coal as a primary energy source release a large amount of PAHs entering air and water systems. Emissions of PAHs are usually larger in winter than in summer, reflecting its association with coal combustion for heating during cold weather (Zhang and Tao, 2008). Vehicles also emit exhaust gas containing PAHs and it has been shown that vehicle numbers were positively correlated with respiratory diseases (Xu and Lee, 2000).

Impacts on ecosystems and human health

It has been observed that the high levels of PAHs at an e-waste site had profound effects on the soil bacterial community, by suppressing or favoring certain groups of bacteria (Zhang et al., 2009). When exposed to water containing benzo(a)pyrene (B[a]P), DNA adducts and DNA strand breakages in mussels occurred within the first three days, reflecting the strong carcinogenic effect of benzo(a)pyrene (Ching et al., 2001). In terms of human toxicology, the mutagenic and carcinogenic properties of some PAHs are of major concern (Walker, 2001).

Geographical scope and transboundary transport

Petroleum hydrocarbon trade is the major source of transboundary PAH transport in the world. Both crude oil and its refined products contain around 15-20 % of PAHs, e.g., crude oil from Kuwait contains 21.9 % of PAHs (SCPMEU, 1985). Crude oil or its refined products are transported from the oil producing regions to America, Europe, China, Japan, and Australia, with shipping accidents and oil spills commonly occurring in international waters, coastal waters, and harbors. Approximately 12 such accidents occur every year along China's coastal waters (Zhou et al., 1995). The recent oil spill in the Mexican Gulf is an example of a serious accident. As more deep-sea drilling for oil may be expected, more difficulties to contain spillages may be expected, affecting large, transboundary regions.

Particles containing PAHs in air could be transported from one area to another. A recent study found rather high levels of PAHs in several lakes from Svalbard, Norwegian Arctic, which were within the range of levels reported for European high mountain lakes and urban/industrialized areas. The PAH levels detected in sediments from three lakes exceeded Canadian sediment quality guidelines, suggesting risks to aquatic organisms (Jiao et al., 2009).

Management options

A variety of techniques is available to determine and monitor releases, fate, transport, and residues of PAHs in the environment and biota. There are also a number of mitigation, substitution, and disposal options available. Many countries have regulations in place.

Intervention need

Under the United Nations Economic Commission for Europe's Convention on Long-range Transboundary

	ECMI Concern Criteria	PAHs							
1	Concern to DC&CEIT	Unknown		Low		Intermediate		High	X
2	Geographical scale of impact	Unknown		Local		Regional	X	Global	
3	Trans-boundary issues	Unknown		Low		Intermediate		High	X
4	Impact on ecosystems	Unknown		Low		Intermediate	X	High	
5	Impact on human health	Unknown		Low		Intermediate		High	X
6	Climate change impacts	Unknown		Low		Intermediate		High	X
7	Economic/social interactions	Unknown		Low		Intermediate	X	High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**0**		**0**		**4**		**4**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate		High	X
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No		Partially	X	Completely	

Air Pollution (LRTAP) PAHs are covered under The 1998 Aarhus Protocol on Persistent Organic Pollutants. The protocol obliges Parties to reduce PAH emissions below the 1990 levels (or an alternative year between 1985 and 1995) (EC, 2001, UNECE, 1998). Given the large amounts of PAHs released to the environment through anthropogenic activities (Zhang and Tao, 2009), combined with its known toxicity and potential for long range transport, a global management mechanism to reduce releases has the potential to contribute greatly towards a safer and more sustainable environment.

Selected comments from respondents

- [Africa] Hot spots are few in - - - , localised in the main harbor.
- [Africa] The focal point of POPs in - - - is located within the - - -. It is very much concerned with these chemicals. However, the office is run by a person who receives no salary. He almost ran out of interest.
- [Africa] National environmental policy, strategic plans and legal legislative management bodies exists in East Africa
- [North America] Exposure to PAHs in indigenous communities due to biomass combustion. Exposure to PAHs in urban-favelas due to small-scale industries (brick kiln communities). Exposure to mixtures of PAHs and benzene in industrial areas.
- [North America] My comments above are more concerned with developing countries, particularly human exposure to PAHs in areas where wood/coal are extensively used for home heating and cooking.
- [Oceania] PAH production especially relates to use of wood and other biomass for domestic cooking. This is also a significant source of dioxins in Pacific Island states, and hence partly covered by actions already required under the Stockholm Convention. No specific controls in any Pacific Island states.
- [South America] Since my country transports are much based in automobiles, this issue is very critical, but wood combustion and slash and burning agriculture and smelters also may play a great role.
- [South America] Multiple and geographically spread occurrence of informal and illegal trash elimination by fire. Soil treatment by fire considered a valid option to prepare lands for crops. Arable lands for crops represent a 20-25% of the country´s territory. Few cities with high concentration of traffic.
- [South America] The most important limitation for an environmental management is the absence of political willingness to do it, and there is no social interest to do something.
- [South America] About ECMI, in the region, by Mercosur international agreement, there are some general regulation about PAHs as Mercosur\Gmc\Res 28/93 Reglamento Tecnico Sobre Envases Y Equipamientos, Plasticos En Contacto Con Alimentos. But nothing specific for ECMI.

- [Southern Africa] There are regulations that manage this ECMI but unfortunately not enforced. As such PAHs are continuously being emitted to the environment (waste burning, black fumes of trucks and buses, etc.). This is true for most of the African Sub Sahara region.

- [Africa] Levels are only measured on an ad hoc basis, e.g. during environmental impact assessments. Last time that PAHs were monitored in the marine environment was in the mid 1980s. PAHs taken up in the national water quality guidelines for marine and freshwater systems. The - - - Programme may include analysis of PAH. However this programme is not yet functional.

- [Africa] In - - - 90% of households energy is from the combustion of biomass. Also there is a lot of crude and refined oil waste available but there is no proper disposal mechanism. Globally - - - contribution is limited because of the availability of so many forms of sinks. There is also a belief that the objectives of MEAs like Abidjan Convention, Stockholm Convention on Persistent Organic Pollutants, UNFCCC, UNCCD, UNCBD, Rotterdam Convention, Kyoto Protocol could address the problems if properly implemented. The ECMI is not specifically yet regulated in - - - but other legislations such as - - - etc. and MEAs could regulate ECMI if enforced.

- [Africa] This area of research needs considerable attention in - - -, for now it is very low. Most DC/EIT countries do not even have PAH as part of their Environmental Impact Assessment criteria requirement for new projects and as such do not have threshold levels. Sometimes the levels of PAH in ordinary kitchen smoke is amazing and could be a contributory factor in the numerous breast cancer cases in rural communities in recent times (this is not proven yet but other studies strongly link the two). Not very well regulated. The regulatory mechanism is very weak. PAH research has just begun and much awareness is yet to created. For long term, identification and monitoring, construction of good kitchens. The short term option could be education. For now there is no awareness as to what PAHs are. Once people become aware, demand for environmental quality will be recognized DC/EIT.

- [Oceania] Currently the issue associate with PAHs in the country does not reach a critical stage as applicable to certain countries, however, requires certain guidelines in the country to be developed to address this growing issue; currently the only law that covers all pollutant is - - - . Part VI looks mainly at pollution control in the country. However, it lacks enforcement since there is no recommended guidelines in the act and regulation to enforce it; PAHs need to be monitored in the country to observe its concentration in our environment.

- [Asia] National standards are requested to apply in EIA reports for developing projects and to assess the present status of environment quality throughout the country.

Arsenic

Description

Arsenic (As) is a natural element of the earth's crust and it is commonly found in soil and minerals. Arsenic topped the list of 275 substances in the 2007 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) List of Hazardous Substances (Agency for Toxic Substances and Disease Registry (ATSDR, 2007). Although classified in the same chemical group as phosphorus (P), As is ubiquitous in the environment and is a class 1 carcinogen (International Agency for Research on Cancer, 2004).

Reasons for Developing Countries and CEIT concern

Releases

Even though the environmental and health impacts of As has been recognized for many decades, its continued impacts in Developing Countries and CEIT, continued production and use, as well as possible climate change interactions, qualifies As as an ECMI.

Elevated levels from releases are brought about by mining, industrial, agricultural, and geological activities (Ross, 1994). Arsenic had various medicinal and industrial usages in the past. Lead hydrogen arsenate has been used, well into the 20th century, as an insecticide on fruit trees. Chromated copper arsenate (CCA) treated timber is still in widespread use in many countries, and the burning of CCA timber resulted in serious animal and human poisonings due to the direct or indirect ingestion of wood ash (Encyclopedia of Chemistry, 2009). Commercial arsenicals are added to poultry feed for growth promotion and prevention of parasitic infections (Nachnam et al., 2005). These organo-arsenicals can be biologically converted into inorganic arsenic resulting in high levels of inorganic arsenicals in young chickens, as well as in chicken manure, which may impose health hazards, and limit the feasibility of waste management alternatives (e.g. turning the manure into fertilizer) (Arai et al. 2003).

Pollution

Groundwater contamination by As as a result of both natural (geological sources) and anthropogenic activities (e.g., ground water abstraction, atmospheric deposition from mining, smelting and refining of non-ferrous metals and other industrial processes including coal combustion, use of pesticides and herbicides), resulted in acute and chronic exposure in many areas of the world, such as a number of Asian countries (Andrew, 2005): e.g., Bangladesh (Hossain, 2006), India (Rahman et al., 2003), Vietnam, Cambodia (Berg et al., 2007), and China (Yu et al., 2007). For example, high arsenic levels in paddy soil of Bangladesh have been reported (Meharg and Rahman, 2003).

Exposure and uptake

The worst affected country is Bangladesh. It has been estimated that 79.9 million persons out of a population of 130 million are exposed to As concentrations in drinking water over 100 mg/L, and in some cases as high as 700 mg/L, due to the digging of tube-wells for water-supply into aquifers with elevated As (Chowdbury et al., 2000). Arsenic can enter the food web. Fish, fruits and vegetables primarily contain organic rather than inorganic As, but dairy products, beef, pork, poultry, and cereals contain mainly inorganic As. A recent study showed 85-95% inorganic As in rice and vegetables (Rahman et al., 2006).

Impacts on ecosystems and human health

Arsenicosis, a form of chronic As poisoning, are commonly observed in villagers in Asian countries (such as India and Bangladesh), who consume As-contaminated drinking water (Mahata et al., 2004). Prolonged intake of As leads to As toxicity with manifestations in practically all systems of the body (respiratory, pulmonary, cardiovascular, gastrointestinal, hematological, hepatic, renal, neurological, developmental, reproductive, immunologic, genotoxic, etc.). The most serious concern is the potential to cause malignant change in many organs. It is estimated that 200 000 – 300 000 people will die of cancer from drinking As-contaminated water in Bangladesh alone (Rahman, 2002). The largest contributor to As intake by Bangladesh villagers in As-affected regions is from drinking water, followed by food, notably rice, and then vegetables. In areas where rice has a high As content, there is a high probability that As intake may exceed dietary guidelines even if the water is deemed safe (Correll et al., 2006). Though the As content of rice is generally below the food threshold values, in communities where people consume large amounts of rice daily, it can easily exceed the total daily intake guidelines (Patel et al., 2005).

Geographical scope and transboundary transport

Movement of As in ground water in regions where there is a high level of As (such as Bangladesh, India, Vietnam, Thailand and Cambodia, and Argentina), and the international trading of food (e.g. paddy rice) and products (e.g. CCA timber) with high concentrations of As are important trans-boundary issues.

Though exposure to drinking water containing high levels of As is a more regional problem, exposure to inorganic As from rice has been recently considered as a global health issue (Zhu et al., 2008). A recent survey on 17 samples of baby rice produced (by three manufacturers) in the UK or EU (without specifying the source of the rice grain used), revealed that 35% of the samples would be illegal for sale in China, whereas there are no food regulations of As in most countries including EU and US (Meharg et al., 2008).

Climate change might affect water tables and geological hydrology, and thereby affect exposure to As. Volcanic ash may also contain As, and may become problems where ash is deposited such as in Argentina (Bhattacharya et al., 2005).

Management options

There are a number of techniques available to analyze and monitor As in a variety of media and products, allowing monitoring of As levels. Various mitigation, substitution, and disposal options are available (Thakur et al, 2011). Regulations have been implemented in some instances.

Intervention need

In view of the extent of some problems, its toxicity, trans-boundary movements (international waters, and international trade), and the number of people exposed, the need for a more concerted intervention is deemed urgent.

Selected comments from respondents

- [Africa] Only when digging artesian wells. I personally accuse this chemical + lead, cadmium & copper of being behind the significant increases of kidney failure & cancer cases, especially in the 2 northern states. I started working with lead. Now I am working with Cd, Pb, Cu & Zn.
- [Africa] Specific deposits poison some African countries ground water.
- [Africa] Currently the issue associate with Arsenic in the country does not reach a critical stage as applicable to certain countries, however the introduction of new mining development in the country can lead to major issues such as other countries are experiencing with Arsenic risks from mining.
- [North America] Arsenic in smelter areas. Arsenic in groundwater. In smelter areas the main concern is exposure to dust in the streets and indoors.
- [Oceania] Arsenic is still commonly used for treating timber in the South Pacific - mainly as copper/chrome/arsenate. Potential problems

	ECMI Concern Criteria	Arsenic							
1	Concern to DC&CEIT	Unknown		Low		Intermediate		High	X
2	Geographical scale of impact	Unknown		Local		Regional	X	Global	
3	Trans-boundary issues	Unknown		Low		Intermediate	X	High	
4	Impact on ecosystems	Unknown		Low		Intermediate	X	High	
5	Impact on human health	Unknown		Low		Intermediate		High	X
6	Climate change impacts	Unknown		Low		Intermediate	X	High	
7	Economic/social interactions	Unknown		Low		Intermediate	X	High	
8	Intervention priority	None		Long-term		Intermediate		Immediate	X
	ECMI CONCERN PROFILE		**0**		**0**		**5**		**3**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No	X	Partially		Completely	

arise from contamination around timber treatment sites, or by localised leaching from the treated timber in use. No specific regulations relating to site contamination in the Pacific Islands, although a few countries now have generic environmental legislation which would allow such controls. General control should also be available under public health legislation.

- [South America] - - - has volcanic activity, therefore As is of naturally occurrence. Some regions in - - - use water associated to volcanic areas to irrigate plants and food crops such as celery or other, for human consumption or exportation. Some communities use freshwater in rivers within volcanic areas without knowing the amount of As in it.
- [South America] The presence of As is only a issue in the water quality control for tap water production. There are few works related to natural As levels presents in natural water of some rivers in east zone, near to border with - - - , where the most part of rice crops are produced. None study has done to evaluate what is the health risk of the human population, of these zone that use directly ground water, or the fisheries get it from the rivers in this zone.
- [Africa] Large scale use in the gold-mining sector but unlikely that routine monitoring specifically for As is required in the environmental management plans or water licence conditions issued to mines by - - -. As taken up in the national water quality guidelines for marine and freshwater systems.
- [Africa] In short, - - - is covered by the - - - sedimentary - - - group which has high levels of arsenic and as a result of the mining activities and acid mine drainage (AMD) appreciably levels are made available to both plant and animals (humans). Arsenic has received much research attention in - - - and is being regulated somehow by the - - - EPA. Its ranks very high in Environmental Impact Assessment criteria for any new project especially mining in - - -.
- [Asia] Contaminated in drinking waters of tubewells

Bisphenol A

Description

Bisphenol A (BPA) is an organic compound used as an intermediate in the production of polycarbonate (PC) plastics and epoxy resins which are widely used in daily life, including digital media (e.g. CDs, DVDs), electronic equipment, automobiles, construction glazing, sports safety equipment, medical devices (e.g. dental sealants), tableware, reusable bottles (e.g. baby bottles), children's toys, and food storage containers. Epoxy resins are also used in the internal coating for food and beverage cans to protect the food from direct contact with metals (Staples et al., 1998).

Reasons for Developing Countries and CEIT concern

Releases

There are many possible routes and mechanisms whereby BPA can be released from products; only some will be related here. BPA can migrate from PC plastic containers and cans with epoxy coating into foods, especially at elevated temperatures (e.g., for hot-fill or heat-processed canned foods). It can also be released into the environment from bottles, packaging, landfill leachates, paper, and plastic manufacturing plants (Yamamoto et al., 2001; Furhacker et al., 2000; Huang et al., 2012). It was estimated that 100 000 kg of BPA were released into air, surface water, or wastewater during 1998 (Staples et al., 1998). According to the US Environmental Protection Agency's Toxics Release Inventory, about 2 000 000 kg of BPA was released into the environment in 2006 across the USA from on-site and off-site disposal by various industrial sectors, municipal wastewater treatment plants, and landfill sites (USEPA, 2006).

Pollution

Bisphenol A can enter the environment and contaminate air, water, and soil, affecting wildlife and human beings. It has been detected in environmental waters in Japan (Water Quality Management Division, 1999), and in water samples from streams in the USA near wastewater treatment plants (Kolpin et al., 2002). According to recent studies conducted in the USA, Germany, Japan, Spain, China, and the Netherlands, the average BPA level in river water was 8 µg/L or less (Kang et al., 2007), but reached 21 µg/L in one sample collected from the Netherlands (Belfroid et al., 2002). BPA is commonly found in effluents from paper or plastic production plants and domestic sewage treatment plants because BPA is incompletely removed during treatment (Rigol et al., 2002; Quinn et al., 2003). Leachates from hazardous waste landfills usually contain high concentrations of BPA (e.g. up to 17 200 µg/L of BPA was found in leachates from a landfill in Japan (Yamamoto et al., 2001).

Exposure and uptake

Widespread and continuous exposure to BPA is primarily through food, but also through drinking water, dental sealants, dermal exposure, and inhalation of household dusts (Lang et al., 2008). BPA has been detected in many canned foods as it comes from the can lining that is BPA epoxy resin, especially in fatty, oily or acidic foods in cans (such as ham, Goodson et al., 2002; sauces, Sajiki et al., 2007; fish, Munguia-Lopez et al., 2005; vegetables, Yoshida et al., 2001; and canned liquid infant formula, Cao et al., 2008).

Brede et al. (2003) showed that migration of BPA from polycarbonate bottles into hot water occurred when the bottles were new. Maragou et al. (2008) observed that BPA migration into boiling water from polycarbonate baby bottles. BPA has also been detected in human urine and blood samples as well as in the placenta and amniotic fluid of pregnant women (Matsumoto et al., 2003; Vom Saal and Hughes, 2005).

Studies conducted by the CDC (Centers for Disease Control and Prevention, USA) indicated that BPA was detected in the urine of 95% of adults sampled in 1988–1994 and in 93% of children and adults tested in 2003–2004 (Calafat et al., 2008). Infants fed with liquid formula are among the most exposed, and those fed formula from polycarbonate bottles can consume up to 13 BPA µg/kg/day (European Food Safety Authority, 2007).

Impacts on ecosystems and human health

BPA disrupts normal cell function by acting as an estrogen agonist (Wozniak et al., 2005) as well as an androgen antagonist (Lee et al., 2003). In animal studies, exposure to BPA has been linked to disturbances of sexual maturation (Howdeshell et al., 1999; Harris et al., 2011), altered development and tissue organization of the mammary gland (Markey et al., 2001), induction of the pre-neoplastic mammary gland (Durando et al., 2007) and reproductive tract lesions (Newbold et al., 2007), increased prostate size (Timms et al., 2005), and decreased sperm production (Vom Saal et al., 1998) in offspring. Exposure to BPA has also been associated with chronic diseases in humans, including cardiovascular disease, diabetes, and serum markers of liver disease (Lang et al., 2008).

Despite a half-life in soil of only 1–10 days, the ubiquity of BPA makes it an important pollutant (Fox et al., 2007). Plastics floating on water eventually decompose and could sink; therefore BPA pollution from polycarbonate plastics is prevalent throughout the water column and not just at the surface (ACS, 2009). Many marine animals such as birds and mammals are affected by plastic garbage - animals are known to swallow plastic bags which resemble jellyfish (Moore, 2008). A review of impacts of plasticizers and BPA on animals with a focus on annelids (both aquatic and terrestrial), mollusks, crustaceans, insects, fish, and amphibians, concluded that BPA has adverse effects on reproduction in all studied animal groups (Oehlmann et al., 2009), and may therefore effect biodiversity.

The endocrine effects of BPA on humans are controversial. Some scientists concluded that these effects can be ignored because the exposure of humans to BPA from food and wine as estimated by European Union scientific bodies (0.0005–0.009 mg/kg/day) is far lower than the reference dose (0.05 mg/kg/day) calculated by the U.S. Environmental Protection Agency as being a safe daily dose for humans over a lifetime of exposure (Gray, 2004). Furthermore, BPA is converted into a harmless metabolite, BPA-glucuronide, which has less estrogenicity, in the mammalian liver (Volkel, 2002; Tsai, 2006). However, others reported that BPA is transferred from the maternal body to the fetus (Zalko, 2003) and causes abnormalities of reproductive organs (Gupta, 2000), advanced female puberty (Howdeshell, 1999), and changes in behavior (Kubo, 2003) in experimental mammals. Based on studies in mice and rats, it is widely accepted that exposure to BPA (from the environment as well as from food) at high levels is potentially detrimental to human health.

There is also concern that BPA may influence human development throughout the fetal period (Rubin and Soto, 2009). Its weak estrogenic activity has been shown to reduce sperm count and sperm activity. Furthermore, BPA may be carcinogenic, possibly leading to the precursors of breast cancer. BPA seems also toxic to liver, and may even be linked to obesity by triggering fat-cell activity (European Food Safety Authority, 2006).

Geographical scope and transboundary transport

BPA is one of the world's highest production and consumption–volume chemicals, with more than 2 million tons produced worldwide in 2003 (Burridge, 2003). The global production capacity of BPA is about 4.7 million tonnes in 2007 (Huang et al., 2012). Widespread and continuous exposure to BPA is primarily through food, but also through drinking water (Huang et al., 2012). Releases of BPA from industry manufacturing or their subsequent usage, to both air and water, may have negative effects on the global environment. Animals ingesting plastic particles (especially marine birds) in remote oceans (Ryan, 2008) may also be exposed to BPA through this route (Betts, 2008).

Management options

Since a clear signal on the health and environmental impacts of BPA is still lacking, available management options are only tentatively listed here. Alternatives and disposal options are available. Some countries and regional groupings have already regulated BPA. There are analytical techniques available to determine its presence in products, biota, and environment.

Intervention need

Due to the uncertainty of possible adverse health effects of low dose BPA exposure, especially on the nervous system and on behaviour, and also the observed differences of exposure of very young children, an expert consultation was organized by WHO in 2010 (International Food Safety Authorities Network, INFOSAN, 2009). The US EPA (2010) indicated that it is considering declaring BPA as a chemical of concern, while in April 2010, the Annual Report of the [USA] President's Cancer Panel argues for a precautionary approach on BPA, among other chemicals (National Cancer Institute, 2010). The US FDA, together with the National Toxicology Program, is also conducting investigations.

Pending the findings of various assessments of BPA, a pronouncement on this health and environmental concerns of BPA relating to Developing Countries and CEIT cannot yet be made. However, it is recommended that this ECMI be closely followed, as it may have significant management consequences in Developing Countries and CEIT if action needs to be taken.

	ECMI Concern Criteria	Bisphenol A							
1	Concern to DC&CEIT	Unknown		Low		Intermediate	X	High	
2	Geographical scale of impact	Unknown		Local		Regional		Global	X
3	Trans-boundary issues	Unknown	X	Low		Intermediate		High	
4	Impact on ecosystems	Unknown	X	Low		Intermediate		High	
5	Impact on human health	Unknown	X	Low		Intermediate		High	
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown	X	Low		Intermediate		High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**5**		**0**		**2**		**1**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No	X	Partially		Completely	

Selected comments from respondents

- [North America] "The Government of Canada today announced it will immediately proceed with drafting regulations to prohibit the importation, sale and advertising of polycarbonate baby bottles that contain bisphenol A (BPA). The Government will also take action to limit the amount of bisphenol A that is being released into the environment". (from the Health Canada website, Oct. 17, 2008). "On June 26, 2009, the Government of Canada announced that it is moving forward with proposed regulations to prohibit the advertisement, sale and importation of polycarbonate plastic baby bottles that contain bisphenol A, otherwise known as BPA, to reduce newborn and infant exposure to this substance" (from the Govt. of Canada website, June 26, 2009).
- [Oceania] No specific import controls in most Pacific Island countries. Some basic monitoring data would be helpful (presence in selected imports, and presence in the population), coupled with import controls, which could be applied in most countries by regulation under Customs Acts. However, the Customs agencies would also need support for monitoring and enforcement.
- [Africa] A recent government funded research programme identified the extent and ecological effects of BPA exposure at selected areas in the country. A framework for identifying research priorities was developed as part of the research programme.
- [Africa] Increasing levels in water

Alkylphenols

Description

Alkylphenols, especially nonylphenol ethoxylates and octylphenol ethoxylates, are high production volume chemicals found throughout the world and are important indoor air contaminants (Ying et al., 2002; Brody and Rudel, 2003; Soares et al., 2008). Alkylphenols such as nonylphenol and octylphenol are mainly used to make alkylphenol ethoxylate (APE) surfactants (detergents), though alkylphenols themselves can be used as plasticisers in plastics, and the derivatives, alkylphenol phosphites, can be used as UV stabilisers in plastics. Alkylphenol ethoxylates (APEOs) belong to the group of nonionic surfactants and are used as detergents, emulsifiers, solubilizers, wetting agents, and dispersants. Nonylphenol polyethoxylates (NPEOs) are found in a wide range of consumer products such as cosmetics and household cleaners, and account for about 80% of total APEOs, and octylphenol polyethoxylates (OPEOs) about 20% (Renner, 1997). Globally, about 500 000 tons of APEs are produced annually. Industrial applications comprise 55%, institutional and industrial cleaning products (30%), and household cleaning products (15%) (Ying et al., 2002). According to Staples et al. (2001), 55% of APEO consumption is by industry, about 30% as cleaners and detergents, and about 15% in household and personal care products.

Reasons for Developing Countries and CEIT concern

Releases

APEOs enter sewage waters or are directly released into the environment from waste. They are incompletely biodegraded during sewage treatment processes and in the environment by loss of the ethoxy groups, resulting in nonylphenols (NP) and octylphenol (OP) and other mono-, di- and triethoxylates (Renner, 1997, Ying et al., 2002). As an example, approximately 60-99 tons of ethoxylated nonylphenol and 12-92 tonnes of p-nonylphenol were annually released to the market in the Czech Republic in 2000-2003 (Czech News Agency, 2010).

Pollution

Alkylphenols have been frequently detected in wastewater and aquatic environments (White et al., 1994; Ying et al., 2002; Soares et al., 2008). Sewage treatment biodegrade less than 40% of nonylphenol polyethoxylates and its metabolites (Warhurst, 1995). During biodegradation, alkylphenol polyethoxylates lose ethoxy groups to become alkylphenols (typically nonylphenol) which are more stable, persistent, and hydrophobic, leading to their accumulation in sewage and rivers (Warhurst, 1995; White et al., 1994), and their volatilization into air. Nonylphenol is lipophylic and tends to bioaccumulate (Warhurst, 1995). Photochemical degradation of nonylphenol will occur, with a half-life of about 10–15 h under ideal conditions (Warhurst, 1995). The more soluble phenols (such as short chain alkylphenol polyethoxylate) have been found in drinking water and groundwater in the US (White et al., 1994).

A recent review from David et al. (2009) points out that alkylphenols are impacting coastal areas near sewage treatment plants. Air concentrations of alkylphenols are rarely reported in the literature but it has been detected indoors and outdoors (Ruder and Petrovic, 2009). Studies in outdoor air have demonstrated elevated concentrations above wastewater-impacted surface waters, for example in the lower Hudson River estuary (Dachs et al., 1999).

No publications were found relating alkylphenols and cross-cutting issues besides international waters, and its widespread use and trade. Its presence in waste and water would imply transboundary concerns. Nonylphenol has been found in air, surface waters, and oceans, and it is likely that residues in the environment will cross borders. It is also used in mining during ore extractions, such as for copper, and discharges may add to environmental pollution.

Exposure and uptake

The major pathways of exposure to these compounds have not been described, but are likely to be dietary and non-dietary ingestion, dermal absorption from product use, and inhalation. A day-care study concluded that dietary ingestion was the primary exposure pathway for toddlers to a group of phenolic compounds that included nonylphenol, though inhalation was found to be a secondary route of exposure (Wilson et al., 2001). Communities near waste dumps may also be exposed to nonylphenol in recycled waste, and from leaching to water and releases to air. Nonylphenol has also been used in pesticide formulations, and it is possible that its use in public health pesticides contribute to human exposure.

Impacts on ecosystems and human health

Nonylphenol has a number of toxic effects. It interferes with respiration in cells, adversely affects calcium transport in muscle cells, inhibits the growth of neural stem cells, increases the production of mammary gland cells, and induces chromosomal aberrations (reviewed by Soares et al., 2008).

4-Nonylphenol and 4-octylphenol have been shown to be estrogen mimics – that is they are able to bind with the estrogen receptor and initiate transcription of estrogen-responsive genes (Bonefeld-Jorgensen et al., 2007). It is expected that these exposures may add to natural estrogens (Silva et al., 2002). A recent study showed that these chemicals can act by additional endocrine mechanisms (Bonefeld-Jorgensen et al., 2007), so assessment of potential health effects is complex. *In vivo* studies in animals show effects at doses between 3 - 10 mg/kg per day (Lee et al., 1999) and concentrations in water as low as 8.2 μg/l (Soares et al., 2008).

Geographical scope and transboundary transport

Alkylphenols may represent a transboundary issue through trade in alkylphenols as compounds and as products with alkylphenols. Another issue can be situations where no sewage treatment is in place, such as many of Developing Countries and CEIT countries. Countries that share coastal zones and receive inputs from sewage may be affected by this kind of pollution.

Management options

Analytical tools are available for monitoring releases, presence, and levels of alkylphenols in the environment and biota. Alternatives are available for some if not all uses. Some countries and regional organizations have banned the use and production of some alkylphenols.

Intervention need

Based on its effects, widespread use and the actions that have been taken by some countries, it is considered that the need for intervention is desirous. The lack of data on use, environmental levels, and human exposure in Developing Countries and CEIT is a gap that needs to be addressed. Therefore, continuous monitoring of the situation is required.

Selected comments from respondents

- [Africa] A recent government funded research programme identified the extent and ecological effects of APE exposure at selected areas in the country. A framework for identifying research priorities was developed as part of the research programme. It is not included in any of the water quality guideline documents. The - - - National Toxicity Monitoring Programme and Chemical Monitoring - - - Programme may include analysis of APE. However this is not measured as a rule.
- [Africa] This area is also now receiving some attention. Research is very low about them. Intervention need - Long Term; Identification and monitoring, short term; education

	ECMI Concern Criteria	Alkylphenols							
1	Concern to DC&CEIT	Unknown		Low		Intermediate	X	High	
2	Geographical scale of impact	Unknown		Local		Regional		Global	X
3	Trans-boundary issues	Unknown		Low		Intermediate	X	High	
4	Impact on ecosystems	Unknown		Low		Intermediate		High	X
5	Impact on human health	Unknown		Low		Intermediate	X	High	
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown		Low		Intermediate	X	High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**1**		**0**		**5**		**2**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No		Partially	X	Completely	

Phthalates

Description

Phthalates or phthalate esters are mainly used as plasticizers (substances added to plastics to increase their flexibility, transparency, durability, and longevity). Phthalates are used in a large variety of products, from coatings of pharmaceutical pills and nutritional supplements, to viscosity control agents, gelling agents, film formers, stabilizers, dispersants, lubricants, binders, emulsifying agents, and suspending agents. Applications include adhesives and glues, agricultural adjuvants, building materials, personal care products, medical devices, detergents and surfactants, packaging, children's toys, modeling clay, waxes, paints, printing inks and coatings, pharmaceuticals, food products, and textiles. Phthalates are also frequently used in soft plastic fishing lures, caulk, paint pigments, and sex toys. Phthalates are used in a variety of household applications such as shower curtains, vinyl upholstery, adhesives, floor tiles, food containers and wrappers, and cleaning materials. Personal care items containing phthalates include perfume, eye shadow, moisturizer, nail polish, liquid soap, and hair spray.

Reasons for Developing Countries and CEIT concern

Releases

Because there is no chemical bond between phthalates and the plastics into which they are mixed, they can be released from products into the environment (Heudorf et al., 2007). This process accelerates as plastic products age and breakdown.

Pollution

Due to the nature of phthalate sources, phthalates are ubiquitous in the indoor environment, with indoor air concentrations generally higher than outdoor concentrations (Rakkestad et al., 2007). Outdoors, urban and suburban concentrations are higher than rural and remote concentrations (Rudel and Perovich, 2009). Although widespread in the environment, phthalates have rarely been measured in Developing Countries and CEIT.

Exposure and uptake

Phthalate metabolites have been detected in virtually all human urine samples tested, indicating widespread exposure. Most exposure studies have concluded that diet is the major route of exposure for phthalates, especially diethylhexylphtalate (DEHP) (Heudorf et al., 2007).

The phthalates are present in materials used in food packaging and processing, as well as gloves used in food handling (Tsumura et al., 2001) indicating exposure and possible uptake. However, other sources such as consumer products make a substantial contribution to overall exposure levels (Fromme et al., 2007). Use of fragrance-containing personal care products is thought to be a considerable route of exposure (Duty et al., 2005a). Some unique exposure pathways include medical equipment for medical staff and patients (intra-venous bags and tubing are made of PVC), some pharmaceutical products, and ingestion of phthalates from teething rings, other toys, and house dust for infants and young children (Heudorf et al., 2007). Dermal absorption of phthalates in personal care products may be an important route of exposure, especially for individuals using large quantities (Janjua et al., 2008).

Impacts on ecosystems and human health

A number of the phthalates have been shown to interfere with androgen production. In animal studies, affected endpoints include; effects on the developing male reproductive tract, disrupted epididymal development, hypospadias, cryptorchidism, retained nipples, and reduced fertility (Henley and Korach, 2006). Most animal studies show these effects occurring at higher exposure levels than are observed in the general human population, although certain medical procedures such as dialysis can result in much higher levels of exposure (European Union, 2008). One human study has shown an association between maternal levels of urinary phthalate metabolites and reproductive tract development in male offspring (Swan, 2006). Associations have also been observed between sperm quality and urinary phthalate metabolite levels in adult men (Duty et al., 2005). In addition, two studies have reported associations between phthalate levels in house dust and allergic symptoms in children (Bornehag et al., 2004; Kolarik et al., 2008). Thus, while animal studies suggest that current exposure levels in the general population are below levels of health concern, some human studies with typical levels of exposure may indicate adverse health effects.

Regarding studies on effects in the environment, Fromme et al. (2002) reports phthalate levels above predicted non-effect concentrations (PNEC) in the aquatic environment in Germany.

Geographical scope and transboundary transport

The main route of transport and dispersion of these compounds on the environmental media is manufactured products trade.

Phthalates are subject to photo-, bio-, and anaerobic degradation and thus generally do not persist in the outdoor environment. Photo degradation half-lives of common phthalates range from approximately 0.3 to 15 days. In remote regions of the Norwegian Sea, where cold temperatures, low concentrations, and lack of nutrients can retard the degradation process. Phthalates have been found despite the lack of a recognized source (Xie et al., 2007). In this case, atmospheric transport and deposition is likely to be the major source, with adsorption of phthalates by snow and ice both slowing down the degradation process (Xie et al., 2007).

Management options

There are adequate analytical techniques to analyze and monitor phthalates in products, biota, and the environment. Mitigation has been affected in many countries and some MEAs by either reducing or banning the use of selected alkylphenols. It is likely that it will be present in products and waste for a long period after any intervention. Further assessment is likely to indicate that mitigation may only need to target specific phthalates. For instance, REACH (EU) states that three phthalates (DEHP, DBP and BBP) that are classified as toxic for reproduction and which act on the endocrine system, shall not be used as substances or as constituents of preparations, at concentrations higher than 0.1% by mass of the plasticised material, in toys and childcare articles (EU, 2011).

Intervention need

Especially in CC&CEIT, there may be a need for more intervention to reduce human exposures (especially babies) and releases to the environment.

Selected comments from respondents

- [Northern America] High levels in at least one industrial area. Some studies have shown high exposure in humans.
- [Oceania] LIkely to be present in imported goods, but no hard data.
- [South America]These compounds are ubiquitous. Most of them are used in unlegally established industries. Also, there is not a well developed understanding that demand the supervision of authorities to assess products from some countries.
- [Southern Africa] This ECMI has not been considered as an issue. This probably as a result of the inability of analytical facilities to test for the compound.
- [Western Africa] Many in the environment.
- [Western Africa] This area is also now receiving some attention. Research is very low about them

	ECMI Concern Criteria	Phthalates							
1	Concern to DC&CEIT	Unknown		Low		Intermediate	X	High	
2	Geographical scale of impact	Unknown		Local		Regional		Global	X
3	Trans-boundary issues	Unknown		Low		Intermediate	X	High	
4	Impact on ecosystems	Unknown	X	Low		Intermediate		High	
5	Impact on human health	Unknown		Low		Intermediate		High	X
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown		Low		Intermediate	X	High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**2**		**0**		**4**		**2**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No	X	Partially		Completely	

Organotins

Description

Organotins mainly include mono-butyl-tin-tri-chlorine, di-butyl-tin-di-chlorine and tri-butyl-tin-chloride (MBT, DBT and TBT), generally called TBTs. There are three more compounds - mono-phenyl-tin-tri-chlorine, di-phenyl-tin-di-chlorine and tri-phenyl-tin-chlorine (MPT, DPT and TPT) - generally called TPTs, but still belonging to TBTs. Therefore, there are a total of six man-made organic tin compounds. Tri-butyl-tin (TBT) is a synthetic organotin commonly used in antifouling paints, as wood preservatives, industrial catalysts, house decorations, coastal equipment, transfer tubing, and as additives to polyvinyl chloride (PVC) to prevent degradation.

Reasons for Developing Countries and CEIT concern

Releases

Industrial production of TBT is the main source for generating these products that eventually can enter the environment. The release of TBTs is mainly from antifouling paints on ships, transfer tubing, aquatic culture tools, and fishery nets. Production of TBTs started in the 1940s and its production increased rapidly. During the1980s, it reached 30 000 000 kg per year, which was 7-fold the amount produced in the 1950s (Omae, 2003). The amount used in China reached 7 500 000 kg in 2001 (Jiang, 2001; Shi, 2003). The release of TBTs from ship paints, wood products, house decorating, and industrial wastes are the main sources of TBTs in the environment in China. Waste and wastewater containing TBTs generated from shipyards and dockyards during routine vessel cleaning and servicing activities amounted to 18 000 m^3 each year in Hong Kong (EPD, 1998), although this might have declined by now.

Pollution

TBT contamination mainly occurs in harbors, estuaries, and coastal areas due to shipping and dock operations. Examples;

- In the Arcqchon Bay of southern France, oyster production in the 1980s reduced sharply to a very low level. The oyster shell became malformed and very thick, while the oyster tissue was very small. This was caused by ng/l levels of TBTs in the seawater (Ruiz et al., 1996).
- Similar damage to marine snails was observed in coastal waters of Hong Kong and Xiamen (China). All the samples of snails (*Thais clavigera*) collected from coastal stations in Hong Kong (with high concentrations of TBTs in seawater) had "imposex" (the masculinisation of female snails) (Tang, 2008).
- Similar TBT contamination and ecosystem damage due to very busy shipping activities and their paint releasing TBTs to harbor waters have also been observed in Hiroshima Bay, Japan (Onduka et al., 2008).
- Tri-phenyl tins were the main organic tin contaminants in snail (*T. clavigera*) collected from coastal waters of Hong Kong (Xie, 2009).

Harbor dredging is a common practice carried out worldwide for preventing harbors from silting up. Dredging operations will result in sediment resuspension and, therefore TBTs originally deposited in sediment would re-enter the water column, which may adversely affect aquatic life. Therefore, TBT contamination in densely populated coastal waters of the world, especially in Asian countries, seems to be a major environmental concern.

Exposure and uptake

TBTs can enter human bodies via seafood, drinking water, and air. Seafood seems to be the most important source of TBT uptake by humans. Some marine organisms can accumulate TBTs - e.g. oysters can bioconcentrate TBTs from water 50 000 times higher than the concentration in water (Waite et al., 1991). Through transfer and biomagnification via food webs, TBTs will enter human bodies through the consumption of contaminated seafood (Taizo et al., 1995; Kannan et al., 1999). Drinking water from water transfer tubing containing antifouling paint could be an important uptake source for humans.

Impacts on ecosystems and human health

TBTs are potent endocrine disruption chemicals that enter the marine environment (Horiguchi et al., 1997). When seawater contains TBTs in ng/l levels, "imposex" is commonly observed in gastropods, with females developing male sex organs. This can result in lower reproduction success.

Malformation is another effect of TBTs on organisms, e.g. the shells of marine bivalves become thick, and the tissue reduced at TBTs in ng/L levels in seawater. Growth and production of crustaceans (crab and shrimp) was reduced by TBT compounds (Nakata, 1998). In addition, TBT compounds can affect the immune system of aquatic organisms, especially fish and marine mammals, possibly leading to diseases (Morcillo et al., 1997).

Geographical scope and transboundary transport

TBTs have been found worldwide in harbors and coastal areas where it has been mainly used as antifouling paints on ships' hulls. Since ships and boats travel, these compounds leach from the paints into water wherever these vessels go, posing a transboundary mechanism for the transport of these compounds.

Management options

There are analytical methods to detect levels of organotins in the environment and biota. Measures have been taken by some countries and MEAs to reduce or ban production and use. Alternatives are available. Wastes and products already treated with organotins may be sources for a considerable time to come. The International Convention on the Control of Harmful Anti-Fouling Systems on Ships of the International Maritime Organization entered into force in September 2008 with certain restrictions and exclusions.

Intervention need

More may be required to further manage, restrict, or ban production of this class of chemicals if the need is identified. It is likely that old treated products as well as organotins as products themselves may find their way into Developing Countries and CEIT, creating or adding to long-lasting releases and exposure. It may be an especially difficult problem to manage in smaller ports and in island states.

Selected comments from respondents

- [North America] There aren´t studies in humans, some in biota, but only in coastal areas.
- [Oceania] TBTs have been previously identified in the Pacific marine environment and may still be used in some applications, especially as antifouling paints. This would include on vessels originating from outside the region. No regulation.
- [South America] PVC is widely used in urban locations in Peru for replacement of old pipes.
- [South America] Sold as antifouling paint. Restrictions in place for - - -.
- [Southern Africa] No knowledge on the extent of use in the marine environment. Ad hoc studies are carried out as part of specific EIAs. TBTs taken up in the national water quality guidelines for marine and freshwater systems. The - - - Programme may include analysis of TBTs. However, this is not measured as a rule.
- [Western Africa] This area is also now receiving some attention. Research is [lacking] about [organotins].

	ECMI Concern Criteria	Organotins							
1	Concern to DC&CEIT	Unknown		Low		Intermediate	X	High	
2	Geographical scale of impact	Unknown		Local		Regional		Global	X
3	Trans-boundary issues	Unknown		Low		Intermediate	X	High	
4	Impact on ecosystems	Unknown		Low		Intermediate	X	High	
5	Impact on human health	Unknown		Low	X	Intermediate		High	
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown		Low		Intermediate	X	High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**1**		**1**		**5**		**1**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No		Partially	X	Completely	

Heavy metals

Description

Although heavy metals have been a long-recognized group of pollutants, they have not received (except for mercury) any coherent international attention. A number of factors that could result in increased releases and exposures, such as mining and manufacture, are expanding globally. This group of pollutants has therefore been identified as an ECMI.

Heavy metals occur naturally with large variations in concentrations. Some heavy metals such as iron, cobalt, copper, manganese, molybdenum, and zinc are required by living organisms, but excessive levels can be damaging, while others such as mercury, plutonium, and lead do not possess beneficial effects and are toxic to organisms. This part of the report will deal with heavy metals, in general, but not mercury (due to current international activities). Arsenic (a metalloid) is described under a separate ECMI topic.

Reasons for Developing Countries and CEIT concern

Releases

The production (mining) of heavy metals has increased exponentially in the world, e.g. the production of lead, copper and zinc accompanied by their releases increased nearly 10-fold since the Industrial Revolution (between 1850 and 1990) (Niragu, 1996). The major anthropogenic sources of heavy metals introduced into the environment include mining, smelting, and industrial activities. In particular, combustion of fuels such as coal that may contain high levels of heavy metals has become an environmental and public health concern in recent years, especially in Developing Countries and CEIT.

Pollution

Mining and smelting, as but one example of heavy metal pollutants source, can cause significant environmental pollution in Developing Countries and CEIT. Examples:

- In both China and India, exploitation of mineral resources took place in the past (since the 1950s), with little consideration for conservation and restoration, generating a vast amount of derelict land, which impose metal toxicity problems to plant growth (Wong and Bradshaw, 2002; Dhar and Chakraborty, 2002).
- The toxic sludge from a zinc mine in the Andes (Bolivia) has killed aquatic life along a 300 km stretch of river, threatening the livelihood and health of 50 000 of the region's subsistence farmers (Edwards, 1996).
- The October 4, 2010, sludge dam collapse in Hungary is another example of pollution from mining activities.
- Relevant to the ECMI "Lead in paint" discussed in this document, is also the recent finding of cadmium in toys (Mead, 2010).

Exposure and uptake

Heavy metals can enter humans via food, drinking water, and air. Fine particles containing toxic metals can be inhaled and pose a health risk. Countries such as China and India will continue to rely on high-ash coal as a primary energy source, posing health and environmental risks (Niragu, 1996).

Although there is good understanding of sources, levels and effects in freshwaters, there seems to be a lack of information on the transport of toxic metals in the ocean. Dissolved metals can be taken up by plants, biota, and human beings. Depending on the element and biotic species, heavy metals can bioaccumulate and may build up in biological systems, posing health and environmental hazards.

Impacts on ecosystems and human health

Some heavy metal elements are needed for humans (and other organisms) in minute amounts (Co, Cu, Cr, Ni) while others are carcinogenic or toxic, affecting different systems, e.g., central nervous system (Hg, Pb, As), kidneys or liver (Hg, Pb, Cd, Cu) or skin, bones, or teeth (Ni, Cd, Cu, Cr). Poisoning could result from drinking contaminated water (e.g. lead pipes), high ambient air concentrations near emission sources, lead in paint, or intake via the food chain. Eaxmple:

- *Itai-itai* disease, a painful, degenerative bone disease caused by industrial cadmium pollution of the food (paddy rice) and water supply in 1950 in Japan, and later observed in other countries such as Thailand and Taiwan, is a typical example. This is mainly due to minimal elimination of cadmium from the body, and its subsequent long elimination half-life of 38 years (ATSDR, 2009).

It is commonly known that extraction of mineral resources by means of surface and underground mining has generated a vast amount of disturbed land area, subject to erosion and resultant metal contamination. Example: Concern has been raised about the high accumulation of toxic metals, in particular cadmium, lead and manganese in birds (based on concentrations detected in feathers), on the successful reproduction of residential and migrated birds in the Mai Po Marshes (Hong Kong, PR China), at the mouth of Pearl River Delta, due to consumption of contaminated food items (Connell et al., 2002), and thereby could potentially lower the biological diversity of this important Ramsar Site.

The heavy metals ECMI is also a crosscutting issue with nano-materials and nano-products, as some of them are based on heavy metals such as silver, gold, and titanium. Some heavy metals are also endocrine disruptive.

Geographical scope and transboundary transport

Heavy metal contamination is a global phenomenon, with many sources and routes of transport. An assessment of human exposure to cadmium, lead, and mercury of both long-range transport and health effects was conducted by the Task Force on the Health Aspects of Air Pollution of the Economic Commission for Europe. It was considered that dietary intake of each of the three metals to be the major route of population exposure related to long-range trans-boundary issue (UN/ECE, 2000). In addition, deteriorating water quality (including toxic metals emitted from mining activities) has been regarded as a priority transboundary issue by Thailand, Vietnam, Laos and Cambodia (Mekong River Commission, 2001).

Management options

There are many analytical techniques available to identify heavy metals in a large variety of matrixes. There are also many techniques available to reduce releases and exposures. There are, however, also many national regulations in place to monitor and deal with environmental levels. Activities and processes have been developed to deal with heavy metals, both internationally (UNEP, WHO, UNIO) and regionally (UN/ECE LRTAP Convention Protocol on Heavy Metals). The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal touched on the control of toxic metals contained in hazardous wastes (*IEA, 2007*).

Intervention need

Interventions in Developing Countries and CEIT may be urgently needed to deal with a major and probably growing pollution problem. Measures to prevent further environmental pollution and to reduce exposures are likely to be major intervention needs locally, regionally and globally. Almost all current initiatives in relation to heavy metals lack a global scope and do not sufficiently address the needs of Developing Countries and CEIT (WHO, 2006).

Selected comments from respondents

- [North America] Exposure to humans and biota to mixtures in mining areas; artisanal communities

	ECMI Concern Criteria	Heavy metals							
1	Concern to DC&CEIT	Unknown		Low		Intermediate		High	X
2	Geographical scale of impact	Unknown		Local		Regional		Global	X
3	Trans-boundary issues	Unknown		Low		Intermediate	X	High	
4	Impact on ecosystems	Unknown		Low		Intermediate		High	X
5	Impact on human health	Unknown		Low		Intermediate		High	X
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown		Low		Intermediate	X	High	
8	Intervention priority	None		Long-term		Intermediate		Immediate	X
	ECMI CONCERN PROFILE		**1**		**0**		**2**		**5**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate		High	X
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No		Partially	X	Completely	

(lead glazed ceramics); exposure in industrial areas; etc. Some metals are regulated in soil and water.

- [Oceania] Some data is available to indicate heavy metal contamination around specific sources such as mines and local industries (vehicle maintenance, boat yards, rubbish dumps, etc). However, the extent of the problem is probably much wider.
- [South America] Yes, - - - has mining activity and some heavy metals are disposed to freshwater, finally going to sea water. Also, there is no efficient control in residual wastes from industries and these residues go finally to the - - - Ocean or to - - - Lake, but sometimes these heavy metals are distributed in - - - River Basin impacting - - -. Identification and monitoring: there are known capacities in universities (private and public) and in some research institutions such as - - - .
- [South America] Mining, smelters and lots of polluted areas all over - - -. Some regulations are in use.
- [South America] There is some environmental management and control, mainly in the capital city.
- [Africa] This is the most studied ECMI in - - - due to the large scale mining in the region. Metals taken up in the national water quality guidelines for marine and freshwater systems. A number of national monitoring programmes address metal issues, e.g. chemical monitoring programme, toxicity monitoring programme and the radio-active monitoring programme.
- [Africa] Its effect is very alarming in the various mining communities.
- [Asia] HM contamination severely affected in many parts especially mining related issues
- [Africa] There are potential risks that are associate with the heavy metals, as a result of poor waste management, unfair trade agreements and weak monitoring of development
- [Africa] The African continent faces challenges with heavy metals released from various activities e.g. mining and mineral processing.
- [Oceania] There are potential risks that are associate with the heavy metals, as a result of poor waste management, unfair trade agreements and weak monitoring of development; currently the only law that covers all pollutant is - - - . Part VI looks mainly at pollution control in the country. However, it lacks enforcement since there is no recommended guidelines in the act and regulation to enforce it; development of national standards and monitoring should be done in the country and also management of any waste that contain these materials for proper disposal at a proper facility.

PRODUCT BASED ECMIs

Nanoparticles and nanomaterials

Description

Nanoparticles (NPs) are normally considered to be particles with at least one dimension <100 nm. NPs can be either from natural origin, erode from manufactured materials (such as paints), or manufactured as such (nanomaterials). With a reduction in particle size, the chemical and physical properties change from the bulk material to NPs; e.g. they have a very high surface to volume ratio, often highly reactive, dispersible, often has colloidal behaviour, high strength, high conductivity, often highly soluble, and often can absorb water and other chemicals. For NPs in the size of 3 nm, almost 50% of the atoms are on the surface (Li et al. 2006; Handy et al. 2008a; Handy et al. 2008b; Warheit et al. 2008; Yang et al. 2008; Wieser et al. 2009).

Because of these changes from bulk materials, NPs are manufactured (also called engineered nanomaterials or ENMs) for use as filters, catalysts, semiconductors, electronics, cosmetics, packaging, food additives, and in medicines, to name but a few applications (Yang et al. 2008; Warheit et al., 2008; Michelson 2008; Bouwmeester et al. 2009). More than a 1000 nanotechnology enabled products produced by more than 480 companies in 24 countries were listed in the product inventory of The Project on Emerging Nanotechnologies (PEN 2009), but this is most likely an underestimation. Of these products, 259 were based on silver, 82 on carbon (e.g. fullerenes and nanotubes), and 30, 35, 50 and 27 for zinc, silicon, titanium and gold, respectively.

Their colloidal behavior places them between chemistry and physics, and their reactive nature and ability to cross membranes attracts attention from chemists and toxicologists. The rapidly expanding research in applications and increased production, with relatively little human health and environmental safety investigations, especially of newer products and applications, requires urgent consideration as to the sustainability of this very promising technology. Releases and exposure will increase dramatically with more NPs and products entering the market (Kahru and Bubourguier, 2010). PEN lists registered projects on human health and environmental impacts (PEN 2009). Nanotoxicology (Suh et al. 2009) and nanoecotoxicology (Kahru and Bubourguier, 2010) is a rapidly expanding field and likely to take a very dominant place in future chemicals management (Handy et al. 2008a and 2008b). While the world is still trying to clean up after the industrial revolution, the current nano-revolution (EC 2009) needs to take head of lessons learned.

Reasons for Developing Countries and CEIT concern

Nanotechnology is a field currently dominated by the USA and many Developed Countries. Since nanotechnology is a developing technology, Developing Countries and CEIT such as India and China have also joined in research and product development (Michelson 2008; PEN 2009). PEN (2009) lists countries such as India, Malaysia, China, Thailand, and Philippines, but many others, such as South Africa, Nigeria, Brazil, and Chile, also have activities in this field (based on a general internet search). The business opportunities and enormous innovation potential are likely to be very attractive for Developing Countries and CEIT to join in on, and offers one of the few current avenues available to become a player in the technology field at the inception level (Michelson 2009). Concomitantly however, so are also the potential risks associated with this new technology, a situation that differs from the normal importing of existing technology from Developed Countries.

Releases

Releases, just as for chemicals, would be possible throughout the life cycle of NPs. Occupational health is likely to become a major consideration, but also releases of NPs after use through waste or other means of disposal.

It may be assumed that eventually the development and use of nanotechnologies will be better regulated in terms of human health and environmental impact (although it is unclear how and by whom). However, based on history and current practice, it is likely that applicable restrictions in Developing Countries and CEIT may be less effective than in Developed Countries, with a consequent likelihood of increased risk in Developing Countries and CEIT. In addition, products and wastes containing NPs, as well as adulterated products may be dumped in Developing Countries and CEIT, contributing towards releases and eventual exposure. A situation akin to e-waste may also be in the offing, and should be anticipated. In fact, many electronic products already contain NPs.

Pollution

There are almost no studies available on engineered NPs in the environment. NPs are extremely small and very few analytical methods have been developed and tested for detection of NPs in the environment after release or use (Lubick 2009). Its behavior in the environment, as well as redistribution, uptake, and compartmentalization in the environment remains largely untested. Coated NPs seems to lose their coatings and may well have properties different from the manufactured particles.

NPs are already used in many products with a consequent release into the environment. Gotschalk et al. (2008) modeled environmental concentrations based on the life cycles of NP containing products (nano titanium, zinc, silver and, carbon nanotubes (CNT), and fullerenes) for the USA, Europe and Switzerland, and compared them to data from toxicological studies. Gotschalk et al. (2008) concluded that risks to aquatic organisms are mainly from nano-Ag, nano-TiO2, and nano-ZnO in sewage treatment effluents, and for nano-Ag in surface waters. No risks to organisms in other modeled compartments (such as soil, sediment, and air) were expected. It seems safe therefore to assume that NPs will enter the environment, are potentially bio-available for uptake by humans and biota, and that there will be some form of biological response (Gotschalk et al., 2008).

The modeled environmental concentrations from Gotschalk et al., (2008) may not be applicable to Developing Countries and CEIT. It is indeed possible that NP production and use intensity, with possible exceptions, will be lower in Developing Countries and CEIT. However, with a lack of adequate sewage treatment in many places, retention and removal of NPs is likely to be much less effective and proportionally more may enter the environment (and possibly the development of a scenario akin to e-waste) - urgent further work (especially modeling; Wiesner 2009) would be very helpful in furthering the understanding of this issue in Developing Countries and CEIT.

Exposure and uptake

Exposure of humans and biota may be through air, water, soil, sediment, food, and direct exposure to products or NPs. These routes are poorly studied for NPs, and are often presumed. Given the lack of environmental information, it can only be implied that communities near waste sites in Developing Countries and CEIT would have increased exposure. E-waste probably already contains NPs. Any mitigating activities regarding e-waste could take NPs into consideration. Interactions with other pollutants also seem possible (Handy et al. 2008b).

Impacts on ecosystems and human health

Even though life evolved in the ubiquitous presence of NPs, very little is understood of the NP/biotic interactions, and even less on ecosystems (Suh et al. 2009; Wiesner et al. 2009). Based on many available laboratory studies on many biological systems, a whole range of effects are associated with NP uptake and only some will be mentioned here: no effect (acute or

	ECMI Concern Criteria	Nanoparticles and nanomaterials							
1	Concern to DC&CEIT	Unknown	X	Low		Intermediate		High	
2	Geographical scale of impact	Unknown	X	Local		Regional		Global	
3	Trans-boundary issues	Unknown	X	Low		Intermediate		High	
4	Impact on ecosystems	Unknown	X	Low		Intermediate		High	
5	Impact on human health	Unknown	X	Low		Intermediate		High	
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown	X	Low		Intermediate		High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**7**		**0**		**1**		**0**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor	X	Intermediate		High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No	X	Partially		Completely	

chronic), retention of particles in various organs, DNA damage, oxidative stress, cytotoxic, cellular damage, inflammation, neurotoxic, teratogenic, antibacterial, inhibition of growth (plants and animals), effects on sperm, and many others (obtained from the following but there are more: Tolaymat et al. 2010; Bouwmeester et al. 2009; Genaidy et al. 2009; Kahru and Bubourguier, 2010; Brar et al. 2010; Warheit et al. 2008; Suh et al. 2009). Kahru and Bubourguier (2010) evaluated available toxicological data and found that NPs ranged from 'extremely toxic' to 'harmful', and some as even more toxic than pentachlorophenol, but none as 'not harmful'. Algae and crustaceans seem to be the most sensitive.

Geographical scope and transboundary transport

Except for trade (and that is assumed since there seems to be no registration in this regard), there is no information that could be traced regarding manufactured NPs. Natural NPs of course will be able to travel along rivers, oceans and via air, but little information on this seems to have been generated.

Management options

Detection of nanomaterials and particles in the environment, as well as its effects, are being developed. Regulations regarding nanoparticles and nanomaterials are also being developed and implemented, but few seem to be in place. Since this is a rapidly developing field, monitoring the situation is proposed.

Intervention need

Based on experience with chemical pollution, timely action is strongly recommended on nanoparticles and or materials when this becomes prudent, especially in Developing Countries and CEIT where intervention after pollution would face considerable difficulties. It would also be very helpful if current and future risk assessment, modeling, and environmental research also take into account situations and conditions relevant to Developing Countries and CEIT, rather than focusing on a narrow set of conditions from Developed Countries.

Selected comments from respondents

- [Africa] Great concern due to reports at experimental levels and increasing industries using this technology. More studies on effects in humans are urgently needed.
- [Africa] - - - has a number of industries developing NPs but no work has been done on the human or ecological effects of these compounds. In April 2010 a research project was launched to specifically address the research, monitoring and management needs associated with this ECMI.
- [Oceania] No data.
- [Africa] Currently there is no distinct major issues in the country that associated with this material

Lead in Paints

Description

Although lead in paints has been recognized as a health and environmental problem for many years, continued and possibly increasing production where regulations are lax, as well as recently expressed concern by Developing Countries and CEIT, qualifies this as an ECMI.

Lead is a heavy metal found in natural deposits. Mining, smelting, use and toxicity of lead are known in antiquity, but the greatest changes in its biogeochemical cycle occurred after the industrial revolution, in particular, after the introduction of leaded gasoline in 1923 (Waldron and Stoffen, 1974).

Due to its high density and resistance against corrosion, lead has been used in a number of applications, such as in paints, gasoline (tetraethyl lead), batteries, as shielding from radiation, projectiles for firearms, solder in food cans, lead-arsenate pesticides, and added to brass to reduce machine tool wear, etc. (Wikipedia, 2009a).

Paint could contain lead used as pigment, with "chrome yellow" -lead(II), chromate lead(II), chromate ($PbCrO_4$), and "white lead" -lead(II) carbonate($PbCO_3$) being the most common. Another purpose for adding lead to paints is to speed up drying, increase durability, retain a fresh appearance, and resist corrosion. Lead paint may still be found in old buildings, even in Developed Countries such the UK, USA, and Australia. It is still sold widely around the world and remains therefore a global concern.

Reasons for Developing Countries and CEIT concern

According to Clark et al. (2009), 73% of consumer paint brands tested from 12 countries contained lead levels exceeding the current US standard of 600 mg/L (standard use since 1978, however the permissible level dropped to 90 mg/L in August, 2009). It was noted that the percentage of samples that exceeded a level of 600 mg/L lead ranged from 33% for China, 37% for Singapore, 90% for Thailand, and 96% for Nigeria. Ten samples from Ecuador contained lead levels up to 32 mg/L. An early report also showed that 100% (n=17) of paint samples from India contained more than 5 000 mg/L lead (Clark et al., 2006). Other studies also indicated the high lead levels contained in domestic paints sold in Nigerian market (Adebamowo et al., 2006; 2007). In a vote by the House by the Representatives of the Federal Republic of Nigeria (Nigeria, 2010), mention of lead at 130 000 mg/l (equivalent to 130 g/l, or 1.3%) in paint was made.

Lead in products has also attracted major international attention. Lead in toys and jewelry has lead to massive product recalls in the USA and elsewhere (Schmidt, 2008). It is possible that some of these products remain in Developing Countries and CEIT without the hazards being known.

Releases

Lead is in the form of particles and can be removed by rain or gravitational settling. Solubility of lead compounds in water is governed by pH, water hardness, salinity and the presence of humic substances. Soil and dust act as sinks for lead, as it strongly adsorbs to soil. Therefore, lead is generally retained in the upper soil layers, with only minimal leaching into the subsoil and groundwater. Lead compounds may be transformed in the environment to other lead compounds (Johnson et al., 2009).

As for leaded paint, pigments in the form of insoluble solids are incorporated into the paint to contribute color, texture, as well as other characteristics. Lead is found in waste sludge produced during paint manufacturing, which typically contain 27.5% pigment, 25% binders, and 47.5 % organic solvents (Johnson et al., 2009).

Pollution

After chipping, flaking, or peeling off, lead paint flakes (even as small as on nano-scale) can be ingested, or inhaled. Even a very small amount of lead paint chips or lead dust can be harmful to human health, in particular, young children (CDCP, 2005).

Exposure and uptake

It has been stated that lead poisoning is the most common disease of environmental origin in the USA today (Landrigan and Todd, 1994). People may be exposed to lead in ambient air through inhalation, food, drinking water, soil and dust (ATSD, 2006). For lead paint, occupational hazards (e.g. painters, maintenance/renovation, and abatement workers dealing with unsafe paint) include elevated blood lead levels. Dermal exposure may be significant for people working with organic lead compounds.

Lead can remain in mineralizing tissue (i.e. teeth and bones) for long periods and can be released into the blood stream especially under calcium stress, such as pregnancy, lactation and osteoporosis, or calcium deficiency. There, it is of particular risk to the developing fetus (ATSDR, 2007).

Children are more likely to be exposed to lead from paint dust, soil, and water due to their hand-to-mouth activities, and because of spending more time on the floor (Bellinger, 2004). It has been claimed that the substantial amount of lead in paints sold in Nigeria that increase the risk of exposure to children, is more important than exposure through leaded petrol (Adebamowo et al., 2006).

Impacts on ecosystems and human health

Toxicity of lead is well documented. Clear evidence of harm has been shown in children with detectable levels of lead in their blood (Lanphear et al., 2000). Lead can damage nervous systems (in particular in young children) and cause blood and brain disorders. Lead poisoning results from ingestion of food or water containing lead, and via accidental ingestion of contaminated soil, dust, or lead paint. Low levels of lead poisoning can give rise to hyperactivity, aggressive behavior, learning disabilities, lowered IQ, speech delay and hearing impairment, while high levels can cause severe mental disabilities, convulsions, coma, or even death (ATSDR, 2006). The role of lead in cognitive deficits in children linking to learning disabilities has been a worldwide concern (Hu, 1991).

In countries or regions where legislation or enforcement is either less stringent or non-existent, the problem is more serious, e.g. it has been reported that childhood lead poisoning is a serious health problem in Africa (Nriagu et al., 1996), Saudi Arabia (Al-Saleh and Coate, 1995), and China (Shen et al., 1996), with leaded paints identified as being the significant source. Even in the USA, Kassa et al. (2000) claimed that lead poisoning is a significant health problem among young children residing in inner-city homes in Toledo, Ohio.

Although white lead paint has been banned in industrialized countries, yellow lead chromate is still in use and has been applied to substantial numbers of structures. There were about 1.3 million homes in California with interior paint lead levels exceeding 5 000 mg/kg, the safety level (Sutton et al., 1995). It was rather alarming to note that lead concentrations over 50 000 mg/kg were detected in a number of pre-1930 buildings, and 10 000 mg/kg for a primary school built in the 1920s (Horner, 2004).

Geographical scope and transboundary transport

International trade of lead paint is the most relevant trans-boundary issue. Many children's toys imported from China were recalled mainly due to lead in paint used to color the product (Schmidt, 2008).

Management options

Lead is routinely analyzed in all manner of media. Regulation and enforcement seems the best management option available, as shown by many countries and some MEAs. Alternatives are available (SAICM, 2012).

	ECMI Concern Criteria	Lead in paints							
1	Concern to DC&CEIT	Unknown		Low		Intermediate		High	X
2	Geographical scale of impact	Unknown		Local		Regional		Global	X
3	Trans-boundary issues	Unknown		Low		Intermediate	X	High	
4	Impact on ecosystems	Unknown		Low		Intermediate	X	High	
5	Impact on human health	Unknown		Low		Intermediate		High	X
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown		Low		Intermediate	X	High	
8	Intervention priority	None		Long-term		Intermediate		Immediate	X
	ECMI CONCERN PROFILE		**1**		**0**		**3**		**4**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate		High	X
10	Management option(s) available	Unknown		None		Some		Adequate	X
11	Addressed by MEAs	Unknown		No		Partially	X	Completely	

Intervention need

Intervention is needed for limiting the risk of exposure in addition to measures to increase awareness and enforce regulations leading to the elimination of lead based domestic paint. A number of initiatives are underway, including the establishment of a UNEP/WHO led Global Alliance to Eliminate Lead in Paints (UNEP/WHO, 2010).

Selected comments from respondents

- [North America] Old buildings with very high levels. New sources (new paints) not enough characterized.
- [Oceania] Leaded petrol is no longer used in the Pacific but there may be some issues around residual contamination, eg marine sediments. The recovery and melting of lead (eg. from car batteries) for use as fishing sinkers is a common activity, potentially leading to localised health effects There may also be contamination issues around some of the mines in the region (eg. in - - - and - - -).
- [South America] It is the same situation as the heavy metals described before. In fact, there are some reports of impact on human health in - - - with a group of children below 14 years old that have some learning problems because they are continuously exposed to lead. This topic is included in the general management, that do with the rest of heavy metals.
- [Africa] Strictly regulated... lead banned in paint in my country.
- [Africa] Regulated as part of metal regulation through quality guidelines.
- [Africa] The levels of lead used to be high but has reduced a bit but there are still some in the environment.
- [Africa] Poor regulation ..almost no enforcement. Even the scanty data available in literature has not been well managed in policymaking and regulation etc.
- [Africa] Old problem which should be solved soon
- [Africa] Some projects have been initiated in Africa but more work is required to establish the magnitude of the problem as well as provide mitigation measures.

Inorganic fertilizers

Description

Fertilizers are applied to promote plant growth. Fertilizers are usually applied either through the soil (for uptake by plant roots) or by foliar feeding (for uptake through leaves). Fertilizers can be organic and/or inorganic. Inorganic fertilizers manufactured through chemical processes, or using naturally occurring deposits while sometimes chemically altering them (e.g. concentrated superphosphate). Micronutrient products used to supplement the needs of plants such as for boron, chlorine, cobalt, copper, iron, manganese, molybdenum, sodium, and zinc. Micronutrient products, in particular, may be derived or produced from hazardous waste. While inorganic fertilizers are mainly used in agricultural applications, some of them have also domestic applications in gardens in urban centers

Reasons for Developing Countries and CEIT concern

Releases

Due to the massive use in agricultural activities, inorganic fertilizers are of concern, since releases into the environment is by leaching, run-off, and soil erosion into surface waters. Water pollution by inorganic fertilizers has been widely described; *inter alia* from the Gulf of Mexico (Rabalais et al., 2002) and the Mediterranean (Arhonditsis et al., 2000).

Exposure and uptake

Exposure to toxic components of inorganic fertilizers may not cause a direct human health impact except due to misuse. However the introduction of nutrients (and other chemicals) in agricultural fields may harm groundwater resources and diminish environmental quality and human health. Agricultural nutrient balances differ substantially with economic development, from inputs that are inadequate to maintain soil fertility in parts of many Developing Countries and CEIT, particularly those of sub-Saharan Africa, to excessive and environmentally damaging surpluses in many developed and rapidly growing economies.

Impacts on ecosystems and human health

Eutrophication and harmful algal blooms are some the impacts of inorganic fertilizers reaching water bodies, with consequent human health and environmental consequences. The increasing number of hypoxic/anoxic zones in coastal waters is another effect due to the excess of nutrient loadings by riverine inputs into the ocean (Diaz and Rosenberg, 2008). Impacts on plant biodiversity have also been pointed out recently (Hautier et al., 2009).

In addition, many fertilizers could add the environmental load of heavy metals such as cadmium, lead (EU, 2009), and some chemicals that are covered by the Stockholm Convention. Water eutrophication leads to loss of biodiversity and direct and indirect effects on the human health due to the proliferation of harmful algal blooms as well as economic losses

	ECMI Concern Criteria	**Inorganic fertilizers**							
1	Concern to DC&CEIT	Unknown		Low		Intermediate	X	High	
2	Geographical scale of impact	Unknown		Local		Regional	X	Global	
3	Trans-boundary issues	Unknown		Low		Intermediate	X	High	
4	Impact on ecosystems	Unknown		Low		Intermediate	X	High	
5	Impact on human health	Unknown		Low	X	Intermediate		High	
6	Climate change impacts	Unknown		Low	X	Intermediate		High	
7	Economic/social interactions	Unknown		Low	X	Intermediate		High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**0**		**3**		**5**		**0**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No		Partially	X	Completely	

associated with declining fisheries and other marine life. Loss of plant biodiversity attributed to excess of fertilization has been recently raised as of concern (Hautier et al., 2009).

Geographical scope and transboundary transport

The issue of artificial fertilizers may affect international waters such as the Gulf of Mexico and the Mediterranean, areas heavily affected by water eutrophication. Some problems are indicated by the presence of hypoxic zones in the Gulf of Mexico, Gulf of Bothnia, and the Mediterranean Sea (Nelleman et al., 2008).

Management options

Regulations and other measures are available to manage correct application, and when required, to reduce its use to acceptable levels

Intervention need

There is a clear need for intervention, but it is expected that the effects are regional and their occurrence is global (UNEP, 2008).

Selected comments from respondents

- [Oceania] Artificial fertilizer use is relatively limited in the Pacific because of coasts. However, it would still be moderately significant in the few countries with significant levels of agriculture. The impact on water supplies and the marine environment is unknown but probably quite minor alongside other contamination sources such as wastewater/leaching from septic tanks, etc.
- [South America] Fertilizers are used in excess, bad agricultural practices. People believe that it is necessary to use more than the necessary amount to produce food crops.
- [South America] High use all over the country. As far as I know, new factories are being constructed in - - - to improve its uses.
- [Africa] Sewage pollution has a greater influence on eutrophication of water bodies than fertilizers. Nutrients taken up in the national water quality guidelines for marine and freshwater systems.
- [Africa] Uncontrolled fertilizer application is causing the eutrophication of some water bodies.
- [Africa] Acidification of soils, release of biogenic gases
- [Africa] Further studies are required on good agricultural practices and substitutes for inorganic fertilizers

Cadmium in Fertilizers

Description

Cadmium (Cd) is a heavy metal commonly occurring in the earth's crust and in oceans coming from gradual erosion and abrasion of rocks and soils, and from forest fires and volcanic eruptions. It is produced mainly as a by-product of mining, smelting and refining of zinc. Atmospheric deposition from anthropogenic activities such as waste incineration, non-ferrous metal production, iron and steel production and fossil fuel combustion are the major sources (Hutton et al., 1987).

Cadmium is produced in countries where zinc is refined, not necessarily in the countries where zinc ore is mined, with China, Japan, and Korea the world's largest producers. China is also the world's largest consumer of Cd, mainly for the manufacture of batteries. It is used in different products (pigments for plastics, ceramics and enamels, stabilizers for plastics, plating on iron and steel, and element of some lead, copper and tin alloys), and in particular in batteries, until it was banned in a number of countries. Some of these uses have been phased out in Developed Countries, but have continued or even increased in Developing Countries and CEIT.

Reasons for Developing Countries and CEIT concern

Releases

Cadmium is a common impurity in zinc ores. It is also an impurity naturally occurring in most phosphate ores, because most of phosphate rock deposits are of sedimentary origin, which usually contain higher levels of Cd than those of igneous origin. Many soils, in particular in developing countries, are deficient in phosphorous, and therefore overuse of phosphorous fertilizers can cause elevated levels of Cd in soils, leading to higher uptake by crops (van Balken, 2004).

Animal manure also contains a substantial amount of Cd due to its presence in grazed herbage, and impurities in P feed-additives. Therefore, intensive land application of Cd containing manure may have a severe health risk. Soils may also contain Cd pending on the parent rocks. Crops grown in soil contaminated with Cd or irrigated with water contaminated by Cd may absorb the metal, with food crops such as rice and tobacco representing the main sources of Cd intake for non-occupationally exposed people.

Pollution

Cd is present naturally in air, water, soils, and foodstuffs, as it is rather water-soluble, and tends to bioaccumulate such as in shellfish, fish, and plants. The major concern of Cd pollution is contamination of foodstuffs, in particular shellfish and rice.

Some fertilizers, especially those designed to supply micronutrients (in particular zinc, an essential plant nutrient), may incorporate industrial wastes or industrial by-products such as electric arc furnace dust, tire ash (from combustion of tires for energy recovery, which is high in Cd), and mine tailings (high in Cd and other toxic metals). Artificial fertilizers may also contain other toxic metals such as lead, arsenic, chromium, and nickel (Mortvedt, 1996). It was noted that zinc sulfate, a raw material, contained extremely high concentrations of Cd (Washington, 2000). More recently, a similar contaminated shipment of zinc sulfate intended as feed additives was found in Belgium (Animal Nutrition Section, 2006).

Exposure and uptake

The major route of Cd exposure in industrial settings (such as metal plating, production of nickel-cadmium batteries, pigments and plastics productions), and environmental settings (such as the burning of fossil fuels and municipal wastes) is inhalation. However, there have been notable instances of toxicity due to long-term exposure to Cd in contaminated food and water (Haynes, 2007). In addition, inhalation via cigarette smoking is another source of Cd for smokers (Friberg, 1983).

It is well documented that the use of chemical phosphate fertilizers gave rise to elevated metal content, especially Cd in agricultural soils, in a number of countries (e.g., Norway: Singh, 1994; Australia and New Zealand: McLaughlin et al., 2000; UK: Jones et al., 1989).

For rice producing soils in Asia, this would be a special problem in some paddy soils because rice grown on Cd contaminated soils may cause human kidney disease, and Southeast Asian developing countries do not seem to have sufficient fertilizer safety regulations.

Impacts on ecosystems and human health

Cadmium is a nephrotoxicant and accumulates in the kidney throughout life. It combines with cadmium-binding proteins, leading to damage of kidney cells. In addition, Cd is also a reproductive toxicant and cardiovascular toxicant (Stine and Brown, 2006).

Furthermore, the Department of Health and Human Services (DHHS) stated that Cd and Cd-compounds are known human carcinogens (ATSDR, 2008).

The World Health Organization (WHO, 1972) determined a maximum intake of Cd of 1 µg/kg body mass. This has remained unchanged until its review in 2003. In 1994 and 1995, the Organization for Economic Co-operation and Development (OECD) stated the need for reducing exposure to Cd and that accumulation of Cd in soil, from all sources, should be minimized, and also encouraged the development of technologies for removing Cd from phosphoric acid. The Scientific Committee on Problems of the Environment (SCOPE) in 2002 and 2003 considered that there was no conclusive evidence of any adverse impact on human health due to Cd in P fertilizers. Nevertheless, the European Commission drafted a directive that would have set strict and harmonized limits on permitted Cd levels in P fertilizers. Because of three countries in the EU (Austria, Finland and Sweden), the Commission has not reached a decision on the matter due to the concerns of the fertilizer industry on the lack of scientific basis for the thresholds set, of economically viable solutions to reduce Cd levels phosphate fertilizers, and the subsequent market distortions triggered by near monopoly situations (SCOPE, 2003).

"Itai-itai" (ouch-ouch) disease, observed in residents (especially older women) near Jinzu River in Japan was caused by severe osteoporosis and kidney dysfunction, due to consuming rice irrigated by water receiving discharges from mine operation (with Cd and other heavy metals) (Nogawa et al., 2004).

Geographical scope and transboundary transport

While pollution from anthropogenic sources may involve trans-boundary issues through air and water transport, the trade of Cd contaminated products is a major concern. This is especially true regarding the trade in fertilizers that are highly contaminated with Cd, in particular fertilizers which are mixed with mine waste rocks, smelting waste and ash.

Management options

Monitoring of sources, regulations, and technologies can be introduced where needed.

Intervention need

UNEP established a Lead and Cadmium Group in 2005 to review scientific information on Cd in relation to existing national, regional, and international regulations on Cd disposal and use. The effort is still progressing, but mainly focuses on transboundary movement of Cd through air and water, and international trade, in addition to the disposal of Cd in developing countries (International Fertilizer Industry Association, 2009).

Nevertheless, in view of the global use of phosphorous fertilizers, intervention is needed to prohibit the mixing of waste materials, which contain high concentrations of Cd, as well as other undesirable chemicals, into fertilizers.

	ECMI Concern Criteria	**Cadmium in fertilizers**							
1	Concern to DC&CEIT	Unknown		Low		Intermediate	X	High	
2	Geographical scale of impact	Unknown		Local		Regional	X	Global	
3	Trans-boundary issues	Unknown		Low		Intermediate	X	High	
4	Impact on ecosystems	Unknown		Low		Intermediate	X	High	
5	Impact on human health	Unknown		Low	X	Intermediate		High	
6	Climate change impacts	Unknown		Low	X	Intermediate		High	
7	Economic/social interactions	Unknown		Low		Intermediate	X	High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**0**		**2**		**6**		**0**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No		Partially	X	Completely	

Selected comments from respondents

- [North America] No significant data. However, there are no known major sources and any contamination would have arisen through imported products. Most likely an issue around rubbish dumps.
- [Oceania] No significant data. However, there are no known major sources and any contamination would have arisen through imported products. Most likely an issue around rubbish dumps.
- [Africa] There is increasing levels of cadmium in soils of farmlands after long application of fertilizers and that is worrying.
- [Africa] Capacity needs to be built on the African continent to ensure that studies are conducted in this field to establish the magnitude of the problem.

Pharmaceuticals and personal care products

Description

Pharmaceuticals and personal care products (PPCPs) include a diverse group of chemicals (more than 3000 different substances) used as medicines such as painkillers, antibiotics, contraceptives, beta-blockers, lipid regulators, tranquilizers, impotence drugs (Ternes et al., 2004), and personal care products such as dental care products, soaps, sunscreen agents and hair care products. Antibiotics are often the largest single group of drugs purchased in developing countries (WHO, 2001).

Reasons for Developing Countries and CEIT concern

Releases

Intact and metabolized pharmaceuticals are excreted by humans and animals and discharged into the aquatic environment via the release of municipal wastewater and direct discharge (in the case of application in fish culture) while personal care products will also enter the aquatic environment through showering and bathing. In general, all municipal sewage, confined agricultural effluents, and specific personal product manufacturing plant effluents are the major sources of these chemicals. Concerning antibiotics, veterinary medicine/livestock husbandry practices, aquaculture, and human medicinal treatment are the major sources (Kümmerer, 2009).

Pollution

The fate of PCPPs in sewage treatment plants is dependent on the process and efficiency. In many cases the substances pass through the plant more or less unchanged. In some cases the substance is metabolized, inactivated and destroyed, and in other cases, conjugates are cleaved and freed, with active substances released into the aquatic environment (Thompson et al., 2005). Environmental concentrations of various PCPPs have been reported in different countries including Japan, Denmark, Germany, UK, USA, and Brazil (Richardson et al., 2005). Synthetic sex steroids, antibiotics, cytostatics, drugs for lowering blood lipid levels, anticonvulsants, beta-blockers and fluoxetine formulations are of environmental concern based on a study on German sewage treatment plants and waters (Ternes, 1988).

The overuse and possible abuse of antibiotics in farming and aquaculture in some developing countries are rather serious (Le and Munekage, 2004). It has been noted that in China 70% of the drug prescriptions are for antibiotics compared with 30% in western countries. Shrimp containing chloramphenicol exported from China, Thailand, and Viet Nam has been banned in Europe and the USA (Chao, 2003). Kümmerer (2009) reviews the use of antibiotics worldwide.

Exposure and uptake

The removal efficiencies of different PPCPs in sewage treatment plants vary considerably due to the low concentrations of individual PPCPs and their properties. Because of their low volatility, their distribution through the environment will mainly occur through aqueous transport and food chain dispersal (Richardson et al., 2005).

Impacts on ecosystems and human health

There is a severe lack of information on the adverse effects of PPCPs on aquatic organisms, except for some standard acute toxicity data reported for some pharmaceuticals (Pascoe et al., 2003). In addition, information on the fates and effects of PPCPs in the environment is mainly derived from studies conducted in Europe and the USA, and such data is very limited for Developing Countries and CEIT. Nevertheless, some studies on the toxicity of different PPCPs on aquatic organisms have been reported, e.g. green algae (ciprofloxacin, Halling-Sorensen et al., 2000), endocrine disruption in fish (ethynylestradiol and four alkylhenols, Jobling et al., 1996), reduction in population and changes in sex-ratio in amphipod (ethynylestradiol, Watts et al., 2002), and estrogenic effects on spotted sea trout (tamoxifen, Thomas and Smith, 1993).

A high-profile case of pharmaceutical impact is the vulture mortalities caused by diclofenac. Cattle treated with diclofenac and later being consumed by vultures caused renal failure in vultures, leading to large-scale mortalities in Asia (Oaks et al., 2004). This unexpected effect indicates that risk assessment of chemicals through various means may not always be able to capture significant non-target impacts.

Antibiotics are an important group of pharmaceuticals in most developing countries, contributing to the dramatic fall in morbidity from communicable and infectious diseases over the last 50 years worldwide (WHO, 1996). China was the world's top producer of pharmaceutical products in 2003, with an annual production of 28 000 tons of penicillin (60% of the world total), 10 000 tons of terramycin (65% of world total), and ranked first among all nations for doxycycline hydrochloride (a tetracycline species) and cephalosporins, in addition to consuming larger quantities of antibiotics than in other countries.

Overuse and abuse of antibiotics (especially the use of the same antibiotics for both humans and animals) have given rise to disproportionately higher levels of pathogen resistance in developing countries compared to Developed Countries (WHO, 2001). Furthermore, sufficiently high concentrations of antibiotics could also alter microbial community structures, and subsequently adversely affect higher food web components and impose genotoxicity (Richardson et al., 2005). It has been demonstrated that the use of farm manure and pond mud (from fish ponds) containing high concentrations of antibiotics (such as tetracycline) as fertilizer may impose ecological risks which include alteration of microbial communities and inhibition of soil microbial activities (Wei et al., 2009)

Overuse and abuse of PPCPs, notably antibiotics, may affect biodiversity. Lack of legislation or enforcement in Developing Countries and CEIT may result in uses and exposures that may impact on human health and the environment. Mislabeling and misuse may also contribute towards increased levels in the environment and human exposure.

Geographical scope and transboundary transport

The trans-boundary issues on PPCPs include international waters and trade of PPCPs and products containing PPCPs. Transboundary transport of residues via rivers and oceans is likely.

Management options

Setting and enforcing regulations related to PPCPs may be needed. It is likely that pharmaceutical products, given its bioactive nature, may be of a greater environmental and health concern than personal care products. Mitigation is therefore likely to target this group of compounds.

Intervention need

A review has highlighted critical information on interventions to improve the use of antibiotics by health care providers in developing countries (WHO, 2001). There seems to be an urgent need for international intervention on the use of PPCPs, especially antibiotics and other pharmaceutical products. Since the research on PPCPs has only recently started, it seems prudent that watch on new developments and related health and environmental needs be kept for possible regional or global intervention.

	ECMI Concern Criteria	**PPCPs**							
1	Concern to DC&CEIT	Unknown	X	Low		Intermediate		High	
2	Geographical scale of impact	Unknown		Local		Regional		Global	X
3	Trans-boundary issues	Unknown	X	Low		Intermediate		High	
4	Impact on ecosystems	Unknown	X	Low		Intermediate		High	
5	Impact on human health	Unknown	X	Low		Intermediate		High	
6	Climate change impacts	Unknown	X	Low		Intermediate		High	X
7	Economic/social interactions	Unknown	X	Low		Intermediate		High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**6**		**0**		**1**		**2**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor	X	Intermediate		High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown	X	No		Partially		Completely	

Selected comments from respondents

- [North America] We do not have monitoring programs in this important issue, but there is a proposal for regulation in drinking water.
- [Oceania] No data, but most countries have the legislative capacity to control pharmaceutical use
- [South America] It is a group of compounds not studied in Peru. There are some efforts but isolated and with international cooperation at the universities.
- [Africa] This ECMI has not been considered as an issue. This probably as a result of the inability of analytical facilities to routinely test for the compound. It is not included in any of the water quality guideline documents.
- [Africa] Efforts are ensured to properly dispose wastes from this source.
- [Africa] Some of the pharmaceuticals do come to DC/CEIT through unapproved routes and that makes it very difficult for inventory and monitoring.
- [Africa] Increasing levels in water

Illicit Drugs

Description

The illegal drug trade is a global black market consisting of the cultivation, manufacture, distribution, and sale of illegal controlled drugs. Most jurisdictions prohibit trade, except under license, of many types of drugs by drug control laws. A UN report (UNODC, 2003) indicated that the global illicit drug trade generated an estimated $321 billion in 2003.

Illegal drugs may be grown in wilderness areas, on farms, produced in indoor/outdoor residential gardens, indoor hydroponics grow-ops, or manufactured in drug labs located anywhere from a residential basement to an abandoned facility. The common characteristic binding these production locations is that they are discreet to avoid of black market players. Illicit drugs consumed worldwide are comparable with those of therapeutic drugs, as millions of individuals are current users of cocaine, heroin, amphetamine-like stimulants, marijuana and other drugs also in Developing Countries and CEIT. In analogy with that observed for therapeutic drugs, the residues of drugs of abuse persisting in consumers' urine and entering sewage networks with wastewater are also only partially removed by sewage treatment plants (STPs). As a result, these substances are still detectable in treated water and contaminate the receiving surface waters.

Reasons for Developing Countries and CEIT concern

Releases

A preliminary study reported amphetamines in effluents of some STPs in the USA (Jones-Lepp et al., 2004). Cocaine was one of the first illicit drugs to be identified and measured in environmental water samples (Zuccato et al., 2005). Cocaine and its major urinary metabolite (benzoylecgonine, BE) were identified in all wastewater samples tested and in the Po (the largest Italian river). Using the levels of BE to estimate the corresponding loads of cocaine, these authors found that the local drug consumption was considerably higher than current estimates. This quantitative approach - in principle extendable to other illicit drugs - was therefore proposed as an additional tool to estimate drug abuse in real time

Pollution

Drugs of abuse have been measured mainly in Italy (rivers Po, Olona, Lambro and Arno), Spain (Llobregat River), the UK (rivers Thames, Taff and Ely), Belgium (three rivers), Germany (11 rivers) and Ireland (two rivers) and in lakes in Italy (lakes Maggiore, Como and Lugano). Median levels were up to tenths of ng/L for cocaine and BE, a few ng/L for amphetamines, morphine, codeine, methadone and EDDP and trace amounts or below the limit of quantification for the other substances and metabolites. It is also possible that the illegal manufacture of drugs may also contribute towards pollution, not only in areas where drugs are grown, but also in populated areas where illegal laboratories are located.

Exposure and uptake

Illicit drugs are excreted after consumption, as the parent compound and/or metabolites in urine and feces and reach STPs in substantial amounts. Residues of these substances have been documented in untreated wastewater of municipal STPs. Untreated wastewater (influents) of STPs in Spain, Italy, Switzerland, the UK, Belgium, Germany and Ireland contains cocaine at concentrations of hundreds of ng/L (median values), its major metabolite BE at concentrations of μg/L and lower concentrations of other metabolites such as norbenzoylecgonine, norcocaine and cocaethylene (Kaleta et al., 2006). Morphine and 6-acetylmorphine, a specific metabolite of heroin, codeine, methadone, amphetamine, methamphetamine (extacy), ephedrine, ketamine and LSD have also been detected and measured in several STPs throughout Europe. (Kaleta et al., 2006).

Impacts on ecosystems and human health

Most of these residues still have potent pharmacological activities, and their presence in the aquatic environment may have potential implications for human health and wildlife. Even if environmental concentrations are low, threats to human health and the environment cannot be excluded. Morphine, cocaine, methamphetamine, MDA, and ecstasy all have strong activities and their presence as complex mixtures in surface waters - together with residues of many therapeutic drugs - may lead to unforeseeable pharmacological interactions, with toxic effects on aquatic organisms. Drug residues might in fact have biological effects even at low environmental concentrations, as recently reported for mixtures of therapeutic pharmaceuticals (Pomati et al., 2006; 2007).

Geographical scope and transboundary transport

Illicit drugs may represent a transboundary issue in areas where drugs are consumed away from the areas

	ECMI Concern Criteria	Illicit drugs							
1	Concern to DC&CEIT	Unknown	X	Low		Intermediate		High	
2	Geographical scale of impact	Unknown		Local		Regional	X	Global	
3	Trans-boundary issues	Unknown		Low		Intermediate	X	High	
4	Impact on ecosystems	Unknown	X	Low		Intermediate		High	
5	Impact on human health	Unknown	X	Low		Intermediate		High	
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown	X	Low		Intermediate		High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**5**		**0**		**3**		**0**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate		High	
10	Management option(s) available	Unknown		None		Some		Adequate	
11	Addressed by MEAs	Unknown		No		Partially		Completely	

of production, and released in to the environment in situations where sewage treatment is less effective such as many of the Developing Countries and CEIT. It may end up, therefore, in international waters.

Management options

Regulation of these chemicals relies on the strength of enforcement capabilities in different regions of the world. Illicit drug residues in water have much the same concerns as PPCPs, and some interventions would be generic between these two ECMIs.

Intervention need

The production and use of illicit drugs, combined with its potential secondary effects in the environment and humans, provides convincing reasons for intervention.

Selected comments from respondents

- [North America] We were part of a discussion with the health ministry about this issue. However, no funds were available for a study in hot spots areas. However, due to the problems with drug traffic in my country, this can be an important public health issue.
- [Oceania] Recreational drug use is known to occur in most Pacific Island countries. Drug laboratories have been identified in - - -, and some countries are known to have been used as stopover points for smuggling into - - -, - - -, and - - -. No data available on possible environmental impacts.
- [South America] It is a very important problem. - - - is a producer of cocaine illegally. The residues for illegal production is disposed in rivers and soils. When authorities capture the illegal laboratories, finally the cocaine or the cannabis plants, or whatever drug is captured, the residues or captures are incinerated, in fact they are burned without temperature or oxygen control, so it is possible that dioxins and furans are formed during the supposed mitigation action.
- [Africa] It is reported that the use of these compounds has increased significantly over the past 5 years. It is not included in any of the quality guideline documents.

Food additives – Melamine in milk as example

Description

The definition of a food additive is "any substance not normally consumed as a food in itself and not normally used as a characteristic ingredient of food whether or not it has nutritive value, the intentional addition of which to food for a technological purpose in the manufacture, processing, preparation, treatment, packaging, transport or storage of such food results, or may be reasonably expected to result, in it or its by-products becoming directly or indirectly a component of such foods" (Council Directive 89/107/EE, The European Food Information Council, 2009). These included natural or artificial flavorings to enhance or improve the taste of food, or chemicals to change the appearance or texture of food, and prevent bacterial growth.

With the scientific support related to food safety risk assessment and management recommendations from the World Health Organization, the Codex Alimentarius is considering the food safety "measuring stick" for developing countries. The development of the Codex General Standard for Contaminants and Toxins is being developed to differentiate those contaminant limits that are health risk-based from those that are indicators of quality (Moy, 2009). Food adulteration seems to be a serious problem in some developing countries. Industrial chemicals are added to beverages, feed, and food to inflate nutritional content – melamine added to milk to artificially inflate the reading for protein level in quality control tests.

Reasons for Developing Countries and CEIT concern

Releases

Melamine is an organic compound, commonly used in fire retardants and in polymer resins due to its high nitrogen content (66% nitrogen by mass) releasing flame-stifling nitrogen gas upon burning or charring (Bradley, 2008). Melamine has been used as a non-protein nitrogen, appearing in soy meal, corn gluten meal and cottonseed meal used in cattle feed (Reuters, 2008). Melamine was found in pet food exported from China to USA in 2007 causing the death of dogs and cats due to kidney failure, and in baby formula sold throughout China (WHO, 2009). Similar adulteration with melamine was also noted in eggs, traced to melamine being added to animal feed (Wu, 2008). Food items such as canned coffee and frozen yogurt were found to be manufactured using ingredients made from melamine-contaminated milk (WHO, 2009).

Pollution

According to MSDS, melamine is described as "harmful if swallowed, inhaled or absorbed through the skin. Chronic exposure may cause cancer or reproductive damage. After the contamination episode, the Ministry of Health and five other departments in China jointly set the legally acceptable level of melamine content in infant formula at 1 mg/kg, and at 2.5 mg/kg in other dairy products (including milk), while the Chinese Centre for Disease Control and Prevention announced that any amount exceeding 1 mg/kg would be intentional (People's Daily, 2008).

Exposure and uptake

The major hazard and exposure pathway of melamine contained in beverages, food, and feed is through oral ingestion by humans and animals.

Impacts on ecosystems and human health

Thousands of cats and dogs in the USA were killed by eating pet food exported from China in 2007 (Moy, 2009). In addition, 300 000 babies in China became ill, 860 were hospitalized with six fatalities, due to acute kidney failure after having been fed formula milk contaminated with melamine (Macartney, 2008; McDonald, 2008). Ten, four and six children were diagnosed with kidney problems in Hong Kong, Macau and Taiwan, respectively (The Standard, 2008; Macau Daily Times, 2008; Taiwan News, 2008).

Geographical scope and transboundary transport

International trade in tainted products resulted in actions having been taken in receiving countries, as well as at origin.

Management options

Regulations and enforcement are now in place in many countries.

Intervention need

This case demonstrates the impact and power of globalization in food distribution and highlighted the

	ECMI Concern Criteria	Food additives							
1	Concern to DC&CEIT	Unknown		Low		Intermediate	X	High	
2	Geographical scale of impact	Unknown		Local		Regional	X	Global	
3	Trans-boundary issues	Unknown		Low		Intermediate	X	High	
4	Impact on ecosystems	Unknown	X	Low		Intermediate		High	
5	Impact on human health	Unknown		Low		Intermediate		High	X
6	Climate change impacts	Unknown		Low	X	Intermediate		High	
7	Economic/social interactions	Unknown		Low		Intermediate	X	High	
8	Intervention priority	None		Long-term		Intermediate		Immediate	X
	ECMI CONCERN PROFILE		**1**		**1**		**4**		**2**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No		Partially	X	Completely	

need for managing food safety from farm to consumer (WHO, 2008). Although the Codex Alimentarius Commission (a joint FAO/WHO activity) develops guidelines for food safety globally, international intervention is urgently needed. Although melamine in milk is now adequately addressed, other hazardous food additives or hazardous additives in consumer products, may need urgent and coherent intervention.

Selected comments from respondents

- [Oceania] No data. Not specifically, but could be covered under Health Acts, etc
- [South America] After the detection in - - - milk, Health Ministry developed some control procedures. I hope it should be now controlled.
- [Africa] Melamine in milk or other foodstuff strictly prohibited. Milk and dairy products were monitored in my country when melamine scandal in - - - became known to public.
- [Africa] As a knee-jerk reaction international quality guidelines are applied for this ECMI but it cannot be monitored so therefore it is not managed in - - -.
- [Asia] Contamination of food, adulteration in food preservatives etc are severe problem in many developing cities

EFFECTS-BASED ECMIs

Endocrine disruption

Description

The endocrine system in the bodies of humans and animals provides a key communication and control link between the nervous system, and *inter alia,* the reproductive, immunological, behavioral, growth and energetic functions. The endocrine system consists of endocrine glands, the hormones they release, and the receptors in cells of target organisms. The hormones circulate in the blood and regulate various functions via the receptors by interacting with the cell's DNA or other intracellular signal pathways. Examples of such hormones are the thyroid hormones from the thyroid gland, insulin from the pancreas, sex steroid hormones from the gonads, and corticosteroids and catecholamines from the adrenal gland. These hormones regulate various functions through homeostasis.

In general, chemicals that do not originate from the glands or body, but that have biological activities mimicking hormones, have the potential to disrupt the processes regulated or associated by that gland. Such chemicals are called Endocrine Disruptive Chemicals (EDCs; sometimes also used as Endocrine Disrupting Chemicals. Other terms are also used, such as Endocrine Modulators, but here we will use EDCs). The US Environmental Protection Agency (EPA 1997) defines EDCs as *"...exogenous substances that alter function(s) of the endocrine system and consequently cause adverse health effects in an intact organism, or its progeny, or (sub)populations"*. The European Commission (EC) defines EDC similarly as *"... exogenous substance or mixture that alters function(s) of the endocrine system and consequently causes adverse health effects in an intact organism, or its progeny, or (sub)populations"* (EC, 2009). It needs to be understood that naturally occurring compounds such as phytoestrogenic flavonoids also have ED activity (Lui et al., 2010). However, the persistent nature of many of the anthropogenic compounds that have ED effects has attracted a large body of recent literature and EDCs can be considered an ECMI.

Many chemicals have been tested and found to have ED activity with large variations in potencies in one or more test systems. Many classes and types of chemicals are involved, ranging from pesticides (e.g. Clementi et al., 2008), to consumer products, to unintentionally produced chemicals. Many of the chemicals covered by the major chemical conventions have ED activity and effects, even at low levels in the environment. Many of the ECMIs in this report have ED potential, such as the alkylated phenols, bisphenol-A, PAHs, TBT, heavy metals, and PPCPs (especially synthetic hormones).

Reasons for Developing Countries and CEIT concern

Releases

Release sources are myriad and can only be dealt with in general terms, since so many chemicals are considered to have some endocrine disruptive activity. Release patterns in Developing Countries and CEIT are likely to be different from Developed Countries. Some of these chemicals are not produced (or have reduced production) in Developed Countries, while others are almost exclusively produced in Developed Countries. Irrespective of the source, chemicals are likely to end up in the environment during or after use, resulting in human and environmental exposure.

Pollution

As varied as the sources are, so disparate are the types and levels of EDCs in the environment. In almost all cases, humans and biota are chronically exposed to variable mixtures of these EDCs (Kortenkamp, 2007). Products such as pesticide formulations may contain multiple EDCs, all of which will enter the environment and result in exposure to residues. It is beyond the scope of this report to list all cases of where EDCs have been detected, but it can be stated that EDCs are universally, but variably distributed in the global environment.

Exposure and uptake

Routes of exposure and uptake are many. EDCs are present in food, water, air, soil, and products. Uptake would be orally, inhalation, dermal and via fetal transfer.

Impacts on ecosystems and human health

Mixtures of EDCs in varying combinations can potentially have multiple negative effects in biological systems at various levels; genetic, cellular, organ, organismal, community, and ecosystem functioning (Kortenkamp, 2007). The ED activity of DDT has been known since the 1950s, but it has been mainly since the 1990s that concerted concern over EDCs have been expressed. An organism must be able to respond to a host of environmental and social stimuli. These stimuli, whether physical, chemical or social, may act on endocrine tissues and neuronal pathways and endocrine and neuroendocrine secretions that affect physiology, morphology and behavior (Wingfield and Mukai, 2009).

The mechanisms of ED are expressed by:

- Mimicking natural hormones in that it binds to the cellular receptor(s) of a hormone(s) and thereby initiating the cellular response to this signal at a wrong time, or extending it over a longer than normal period.
- Binding to the receptor(s) on the cell surface, but not activating the response, thereby blocking the binding of the natural hormone.
- Binding to transport proteins in blood or other circulating fluids thereby changing the amounts of natural hormones in circulation.
- Interfering with other metabolic processes affecting the rates of breakdown of natural hormones.

Some EDCs may affect more than one such mechanism.

The scope of real (causal relationship shown), associated (strongly suspected), potential, or predicted impacts and effects due to EDC are enormous. The tragic effects of the synthetic estrogen diethylstilbesterol and PCBs in humans, the disturbing decline in sperm concentrations in human males from various parts of the world, the reduction in eggshell thickness in birds due to DDT, imposex in snails, intersex in fish, urogenital birth defects in newborn males, changes in male fertility parameters, and behavioral changes in animals and humans, have either been shown to be caused by EDCs, or have strong associations with EDCs. Not all effects are environmentally mediated, but endocrine disruption remains an ECMI in any case.

ED and the expression of its effects are certain to remain controversial for the near future. However, evidence is mounting of the hazards that EDCs pose, and more and more effects are reported in humans and wildlife. Since many of the EDCs have different potencies and activities (eg. estrogenic, ant-androgenic, androgenic, agonistic, additive, and possibly synergistic), the theoretical foundation (see Soto et al., 2009), measurement and prediction of ED effects from EDCs remain a challenge to be urgently addressed, but complete synthesis is likely to take some time. It can be summarized however, that adequate and compelling theoretical, basic, and real life information is available to urgently consider concerted action.

Geographical scope and transboundary transport

Most of the literature on EDCs concerns releases to or levels of EDC in water via which it can cross boundaries. There may also be cases of some chemicals to be transported by air and accumulate elsewhere; indeed, some of the Stockholm Convention chemicals also have ED properties. A number of chemicals might not meet the criteria for inclusion in existing MEAs, but can be transported via air. Cross-boundary trade in and movement of in products, chemicals and waste containing EDC are of course additional concerns that need to be addressed.

Management options

There are many techniques available to determine ED activity of chemicals, as well as effects in human and the environment Regulations are one of the management options available. Some chemicals with ED activities are addressed by MEAs (such as DDT by the Stockholm Convention). Kortenkamp (2007) strongly advocates EDs for group-wise regulation. UNEP and SAICM are already considering developing on guidance on ED for Developing Countries and CEIT. Under existing EU legislation, chemicals, before entering the market must undergo programmes of testing and assessment in order to ensure that once in use or released into the environment, they pose no danger to people or wildlife. Under this approach, chemicals would undergo testing for hazard identification to be used in a risk assessment. This will determine whether risk management is needed. This existing legislation accounts for detrimental endocrine related effects on reproduction or disease states such as cancer, but does not use endocrine disruption as an endpoint *per se*. However, certain products such as BPA has been banned, based on the precautionary principle, in infant feeding bottles while maintaining the authorisation in other plastic food contact materials with a specific migration limit of 0.6 milligram per kilogram food (EU, 2011).

Intervention need

The urgency to mitigate the known and potential negative effects due to environmental and human exposure to EDCs is getting stronger and more compelling, but the research and knowledge field is still developing, and an active watch on scientific developments and needs of countries is advised.

	ECMI Concern Criteria	Endocrine disruption							
1	Concern to DC&CEIT	Unknown		Low		Intermediate		High	X
2	Geographical scale of impact	Unknown		Local		Regional		Global	X
3	Trans-boundary issues	Unknown		Low		Intermediate		High	X
4	Impact on ecosystems	Unknown		Low		Intermediate		High	X
5	Impact on human health	Unknown		Low		Intermediate		High	X
6	Climate change impacts	Unknown		Low		Intermediate	X	High	
7	Economic/social interactions	Unknown		Low		Intermediate	X	High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**0**		**0**		**3**		**5**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No		Partially	X	Completely	

Mitigating chemicals as EDCs (at low levels of exposure) through international intervention will address many of the other ECMIs identified in this document, would be synergistic to and supportive of existing MEAs, and could achieve an incremental or even quantum improvement in human and environmental health, especially in Developing Countries and CEIT.

Selected comments from respondents

- [North America] Exposure to DDT/DDE at very high levels. Exposure to PCBs in some areas. Etc.
- [Oceania] No data.
- [South America] These compounds are not established as regulated by law despite their importance and impact.
- [South America] Yes, the research done by my research group in - - - River. We defined endocrine disruptions in - - - River, natural border between - - - and - - -. We suggest that the source could be the pesticides used in the basin. The studies was done before the new bleached pulp mill started its works. We had another study where we comparing basins used for soybean crops and forest crops, in - - -, and found endocrine disruption activities higher than the detected in - - - River.
- [Africa] A recent government funded research programme identified the extent and ecological effects of EDCs (i.e. BPA and APE) exposure at selected areas in the country. A framework for identifying research priorities was developed as part of the research programme. Human and ecological effects have been demonstrated.
- [Africa] The research in this area is also catching up.
- [South America] Not formally treated in - - -, with exception to international conventions and protocols.

Chemical mixtures

Description

There are probably now more than 80 000 chemicals in use today, of which 10% are recognized as carcinogens (Pimental et al., 1995). Howard & Muir (2010) compiled an initial list of 22043 commercial chemicals for further assessment. A number of ECMIs in this report refer to exposure of humans and biota to mixtures of chemicals (e.g. endocrine disruption and pharmaceutical and personal care products. Most regulations or interventions deal only with chemicals in isolation and not in combination, reflecting the way that scientific knowledge has been gathered. It is safe to say that the science behind investigating and describing combined effects is not as well developed as that dealing with single exposures. However, biological systems are exposed to a myriad of chemicals on a continuous but variable basis. Life-histories brings living organisms in contact with different combinations of chemicals, while also changing their susceptibilities during development stages. Not only can the chemical mixtures affect an organism directly, they can also affect organisms already stressed by disease.

Reasons for Developing Countries and CEIT concern

The combination of mostly inadequate pollution control of legacy and modern chemicals in many Developing Countries and CEIT with exposure scenarios that often include women and children, as well as most of the world's biodiversity, is likely to increase the extent of the problem of effects of multiple exposures. Combined with a likely increase in the manufacture, import, use, and discard of chemicals and chemical-based products, the complexity of the mixtures are also bound to increase.

Releases

The mixtures of pollutants in the environment are released by all routes as described in the other ECMIs, and is not repeated here.

Pollution

The combined pollution scenarios described in the other ECMIs produces mixtures of chemicals in the environment. This includes all media, such as air, water, soil, and biota, including humans.

Exposure and uptake

Humans and biota are exposed to various combinations and concentrations of chemicals throughout their lifetime (Carpenter et al., 2002).

Impacts on ecosystems and human health

The amount of research on effects of mixtures has recently increased tremendously. There are many ways how mixtures can interact: additively, synergistically, antagonistically, inhibitory, potentiation, and masking (Mauderly & Samet, 2009). A summary of some results are presented:

- Silva et al. (2002) concluded that estrogenic agents are able to act together to produce significant effects when combined at concentrations below their no observed effects concentrations based on the combination of eight weak estrogens on yeast cells.
- Carpenter et al. (2002) reviewed studies of mixtures on human health, such as neurobehavioural abnormalities, hormonal disruption, cancer, cardiovascular disease, etc., and concluded that mixtures do seem to have complex interactions with many of these conditions.
- Sarah & Penn (2004) reviewed studies of exposure to EDCs on behavior of animals and found that pathological behavioral alterations do occur in vertebrates. They especially pointed out that exposures in the environment also occur together with other stressors. Laboratory studies could therefore underestimate the effects in the wild.
- Kortenkamp (2007) also points out that even small differences in mixtures may have entirely different outcomes or effects.
- A review of studies on ozone in combination with other air pollutants found that synergistic health effects are plausible (Mauderly & Samet, 2009).
- Laetz et al. (2009) found that the risk assessment of single chemicals would likely underestimate the impacts of mixtures of these chemicals on salmon in river systems.
- Echeveste et al. (2010) indicated that complex mixtures of pollutants in the ocean have effects on abundance and viability of phytoplankton.
- Kelly et al. (2010) showed that a herbicide combined with parasitic infection significantly affected fish survival, while the stressors in isolation had no such effect.

	ECMI Concern Criteria	Chemical mixtures							
1	Concern to DC&CEIT	Unknown		Low		Intermediate	X	High	
2	Geographical scale of impact	Unknown		Local		Regional		Global	X
3	Trans-boundary issues	Unknown		Low		Intermediate		High	X
4	Impact on ecosystems	Unknown		Low		Intermediate	X	High	
5	Impact on human health	Unknown		Low		Intermediate	X	High	
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown	X	Low		Intermediate		High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**2**		**0**		**4**		**2**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor	X	Intermediate		High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No		Partially	X	Completely	

- Mixtures of common surfactants and chlorinated compounds showed synergistic effects in a laboratory assay (Rosal et al., 2010).

Geographical scope and transboundary transport

It is believed that the exposure to mixtures is a global phenomenon and transboundary in nature, through air, water, and trade. A significant cross-cutting issue of exposure to mixtures is with climate change (Schiedek et al., 2007).

Management options

It is unlikely in the near future, that specific actions will be taken to address chemical mixtures from disparate sources, on a comprehensive global basis. There are some country and regional specific regulations, and the Stockholm Convention is also mandated to address this issue. Any regulation that restrict or ban chemical releases or exposures should eventually contribute towards reduction of that proportion of the chemical in the mixture, but specific action on preventing risks or effects based on mixture effects is likely to be few until the scientific understanding is improved, especially in Developing Countries and CEIT.

Intervention need

The intervention need in Developing Countries and CEIT may possibly be higher than in more Developed Countries due to the mixtures of high levels of legacy and modern chemicals in scenarios with higher releases and/or exposures. However, in the absence of specific studies in Developing Countries and CEIT, intervention needs will be based on precaution, informed by studies from elsewhere.

Selected comments from respondents

- [Africa] Increased exposure of persons to these chemicals
- [Africa] Extensive research at international level should be initiated

PROCESS BASED ECMIs

Electronic-waste

Description

The generation of end-of-life electrical and electronic equipment (EEE) (referred to as waste electrical and electronic equipment, WEEE or simply e-waste) which include personal computers, mobile phones and entertainment electronics has soared in recent decades, with 6 million items generated in 1998 in Western Europe, and 500 million items between 1997 and 2007 in the USA (SVTC, 2008). It has been forecast that the global generation of e-waste will reach 50 million tons per year (SAICM, 2009). The lifespan of the products have become increasingly shorter, with the average lifespan of computers in Developed Countries decreasing from 6 years in 1997 to 2 years in 2005 (SVTC, 2007). This is due to the ever-growing number of new models and need for upgrading. This has resulted in the rapid rise of e-waste, by at least 3-5% per annum, and has in fact become the fastest growing waste stream in industrialized countries (UNEP, 2005).

On average, EEE contains about 38% ferrous, 28% non-ferrous, 19% plastics, 4% glass, 1% wood, and 10% others (Association of Plastics Manufactures in Europe, 1995) which could serve as secondary raw materials. Recycling of e-waste is a prosperous business in some developing countries, such as China, India and in parts of Africa. Significant amounts of valuable materials such as gold, silver, copper, steel, aluminum, wires, and cables can be extracted from WEEE.

Reasons for Developing Countries and CEIT concern

Large quantities of e-waste are shipped from Developed Countries to Developing Countries and CEIT for recycling taking advantage of cheaper labor and possibly less stringent environmental protection laws. In addition to causing human health problems, the toxic contaminants (i.e. heavy metals, notably lead, and persistent organic pollutants, in particular, flame retardants) generated from the open burning of e-waste and the dumping of acid-leached e-waste and ash have caused severe land and water pollution. Poverty is also a characteristic of many of the sites where e-waste is being recycled. E-waste is therefore of particular concern to Developing Countries and CEIT.

Releases

Primitive techniques used to recycle WEEE include:

- Baking electronic boards on top of an open fire (using homemade honeycomb-shaped coals which is a low-grade fuel often made by mixing coal with local contaminated sediment), in order to separate the chips more effectively. This is often conducted indoors, with minimal or no health protection measures, where inhalation of noxious acid fumes may be an important health hazard.
- Stripping of gold from chips and other components using strong acids, with the treated waste dumped along river banks, leading to very low pH and high levels of metals in the sediment and river water.
- Open burning of cable wires (to collect copper), computer casings, and all materials which no longer possess any value, resulting in emission of flame retardants such as PBDEs and chlorinated and brominated dioxins and furans.

There has been substantial evidence showing the export of toxic chemicals from industrialized countries to developing countries, exerting harmful effects on environmental and human health of these countries receiving e-waste.

Pollution

Chemicals including POPs (PCDD/Fs, PBDEs, PAHs, PCBs) and heavy metals (especially lead) is released through open burning of e-waste (containing plastic chips, wire insulations, PVC materials and metal scraps) and contaminates water, air, and soil (Wong et al., 2007). Flame retardants are commonly added in EEE. In an intensive e-waste open burning site in Guiyu, 22 different PBDE-congeners were found.

Exposure and uptake

The released POPs behave as expected. POPs are accumulated from water and sediment in very high levels in fish, close to e-waste burning sites. At one market in China (near an e-waste site), PBDE levels in tilapia were 600 – 15 000 higher than market fish from Canada and the USA (Luo et al., 2007a). Not only are predatory fish exposed to the highly contaminated fish, but so are the humans that consume them.

Impacts on ecosystems and human health

The concentrations of different POPs in different human tissues (including milk, placenta, and hair) of residents near two intensive e-waste recycling sites in China were significantly higher than those from a reference city (Bi et al., 2007). When comparing with results obtained in the 3rd WHO-coordinated study, in which all human milk samples were collected after 2000, Taizhou ranked 10th of the total 32 countries/regions, and topped the list with regards to WHO-PCB-TEQ values. The route of uptake was via fish, as none of the maternal milk donors worked at an e-waste site. The levels of PCDD/F, PBDE and PCB in breast milk poses a severe health hazard to infants from various cities in China, as their intake exceeds the WHO Tolerable Daily Intake many times, in some cases more than 200 times (Chan et al., 2007; Chan, 2008; Leung et al., 2010; Nagayama et al., 2007; Xing, 2008).

Not only do the levels in fish pose a health hazard to humans, these contaminated sites are also expected to experience severe biological stress due to the combined presence of many of the pollutants in high levels in water, sediment, and biota.

Geographical scope and transboundary transport

As a result of China's tightening up of measures on the illegal imports of e-waste and in addition to the exponential global growth of e-waste, a large amount of e-waste is now stored in Hong Kong (91 sites reported, close to the Chinese border) which has become a stopover for illegal cross-border trade in e-waste. It is envisaged that the illegal transboundary transport of e-waste will shift to other developing countries, for example, Vietnam and Zimbabwe, for disposal and crude recycling, repeating the same mistakes observed in China.

In Hong Kong, there are several WEEE programs to handle domestic e-waste – involving recycling workshops for the refurbishment of useable equipment. Items that are beyond repair are dismantled and their useable components and materials recovered for reuse and recycling. A computer recycling program and mobile WEEE collection centre was initiated in March 2008. The Hong Kong Government has built a 20 ha recycling EcoPark that will handle 250 tons of e-waste annually. This is a government-subsidized three-year pilot recycling scheme. The recycling centers will sell some of the processed waste depending on the market situation.

The questionnaire to this report also brought to light that e-waste handling is increasing in Oceania and Western Africa (see Comments from respondents, below). It is likely that other regions may experience similar increase in e-waste traffic.

Management options

Movement of e-waste between political boundaries is governed by The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, in which e-waste is included under List A of Annex VIII of the Convention, considered as dangerous to humans and the environment. It was adopted 20 year ago on March 22, 1989 and entered into force on May 5, 1992. Transboundary

	ECMI Concern Criteria	Electronic waste							
1	Concern to DC&CEIT	Unknown		Low		Intermediate		High	X
2	Geographical scale of impact	Unknown		Local		Regional	X	Global	
3	Trans-boundary issues	Unknown		Low		Intermediate	X	High	
4	Impact on ecosystems	Unknown		Low		Intermediate		High	X
5	Impact on human health	Unknown		Low		Intermediate		High	X
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown		Low		Intermediate		High	X
8	Intervention priority	None		Long-term		Intermediate		Immediate	X
	ECMI CONCERN PROFILE		**1**		**0**		**2**		**5**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No		Partially	X	Completely	

movements of hazardous waste (including e-waste) are restricted, and prior written notification of the exporting country to the competent authorities of the importing country is needed.

Intervention need

International intervention is urgently needed, as the problem is likely to increase. E-waste has many dimensions and crosscutting issues, but the threats present at some sites strongly indicate the need for urgent prevention and remediation.

Selected comments from respondents

- [North America] A national study showed high amount of sources and few industries for the management of it.
- [Oceania] E-waste volumes are increasing rapidly in Pacific Island countries and there are no significant treatment/disposal options available other than export. Some countries are considering deposit systems as a way of funding the exports, but most still have a long way to go in terms of setting up the appropriate waste management systems (for these and many other wastes). Fortunately, the region is now starting to see a significant amount of development work in this area which should lead to some gradual improvement over time.
- [South America] It is a very important problem because of the amount of e-waste.
- [South America] The most important limitation for environmental management is the absence of political willingness to do it, and there is no social interest to do something.
- [Africa] Other than - - - is probably the greatest generator of this ECMI in Africa no issues have yet been identified. Some of the larger manufacturers of electronic compounds do have a limited number of e-waste collection points. What happens to it afterwards is unknown.
- [Africa] E-waste is a serious environmental health in - - - and the huge ignorance of the local people has even worsened the situation. At present, my research team is working on the e-waste environmental health problems in - - - and the West Africa sub-region having presented papers on this in various international conferences. E-waste is regulated, but only recently policy makers began to talk about it albeit without scientific data. Accessibility of those with scientific data to those in government is almost not possible because of what is tagged possibly "- - - bureaucratic bottleneck".
- [Africa] The problem has to do with the bringing in of used electrical and electronic equipment which sometimes do not work at all. DC/CEIT is increasingly becoming a dumping ground for these materials from all over the world. Due to the lack of proper waste collection systems, most of them end up burnt in open dumps releasing all kinds of toxic gases. Others too find their way into water bodies thereby polluting water bodies.
- [Asia] Recycling of electronic waste has posed sever problem on the heatlh of workers and also metals have contaminated the surrounding ecosystem.
- [Africa] Electronic wastes issues has been growing steadily over the years due to introduction of high technology equipment from abroad.
- [Africa] This matter is critical to the African region and needs immediate attention to ensure that lives are saved from the hazardous substances contained in e-waste.
- [Oceania] Electronic wastes issues has been growing steadily over the years due to introduction of high technology equipment from abroad; the Environment Act needs to be reviewed to fully capture the hazardous materials in items such as electronic waste and also the country still lacks a national hazardous waste management strategy; recycle of electronic waste could be a best option in the country, furthermore, proper disposal facilities must be established, if not, transporting wastes to any nearby country with proper facilities for disposal could be a option.

Marine debris

Description

Marine debris can be defined as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment (UNEP, 2009). Marine debris (also known as marine litter or marine plastic pollution) seems to become a growing and apparently intractable problem globally. Debris, mainly from land-based sources such as waste sites and discard via rivers, as well as marine sources such as litter from ships and discarded or lost fishing gear, float or sink in all the world's oceans and seas. Apart from the serious impact by its physical presence as an eyesore on beaches and coral reefs, it also poses a danger due to ingestion, entanglement, and as a sink and source of chemical pollutants. It can be safely assumed that Developing Countries and CEIT are also significant sources of marine debris.

Reasons for Developing Countries and CEIT concern

Developing Countries and CEIT are mainly located in the more temperate and tropical areas of the world, and therefore tourist destinations. Aesthetic impacts cannot be tolerated on beaches and coral reefs, and may impact on the quality of local experience, thereby impacting on income. Many Developing Countries and CEIT are also dependant to a greater or lesser extent on food from the seas, and any impact of marine debris on production and quality of marine foods will also impact on subsistence livelihoods and economies. Since a high proportion of biodiversity is located in or near Developing Countries and CEIT, impact on this biological treasure will compromise conservation and sustainability.

Releases

Marine debris has many sources: Land-based from landfills, riverine transport, direct sewage discharges, industrial waste discharges, direct dumping, and tourism. Sea-based sources are civil and military vessels, fishing boats, oil and gas platforms, and aquaculture installations (UNEP, 2005). The nature of this debris is mainly plastic in substance (often pellets or micro plastics), but many other types of debris, such as glass bottles, light globes, and gas bottles can be found. Sinking debris is often found near estuaries and even in deep water (Galil et al., 1995) and the abyssal plains. In 1997 it was estimated that 6.4 million tons of debris entered the oceans yearly. Other estimates found that perhaps as much as 8 million items of plastic enters the oceans daily, most from ships (UNEP, 2005).

Pollution

Due to currents, debris is distributed globally, including polar regions and isolated tropical islands. In addition, due to oceanic gyres, it seems as if there is a concentration of floating debris in the five oceanic gyres. Since much of the materials are not readily biodegradable, it is likely that the debris will remain for years, even decades, with more debris being added every year (Leous & Parry, 2005; 200UNEP, 2005).

Exposure and uptake

Apart from the aesthetic impacts, there are also physical and chemical impacts on aquatic biota, as well as secondary uptake and transportation of chemical pollutants.

Impacts on ecosystems and human health

Broken glass, syringes and other bits and pieces can cause physical injury and infection to humans and animals, while lines, rope, nets, and wrapping can entangle biota. Blocking of sunlight by plastic sheets can kill corals, while ropes and other pieces can physically damage the reefs. Small pieces of debris can be mistaken for food and ingested by animals from whales, fish and birds, to mussels. This can cause constriction and/or loss of appetite, and kill the animals. Discarded fishing gear can continue to trap and entangle animals for many years. Plastic can accumulate chemicals from water, including many of the POPs (Frias et al., 2010) and heavy metals (Ashton et al., 2010)) be taken up by animals that ingest them (Leous & Parry, 2005; Ocean Conservancy, 2007; Sheavly & Register, 2007, UNEP, 2005, 2009), possibly causing harm as endocrine disruption and mixture effects described elsewhere in this report. Debris may even pose a threat as a vector for invader species (Derriak, 2002).

Geographical scope and transboundary transport

The problem of marine debris is obviously global. Due to currents, debris is able to travel thousands of kilometers, thereby making it a transboundary issue, as well as an issue for Areas Beyond National Jurisdiction (ABNJ). Little attention seems to have been given to the larger landlocked seas, lakes, and deltas. These areas, due to their restricted volumes, may be even more susceptible to effects of debris.

	ECMI Concern Criteria	Marine debris							
1	Concern to DC&CEIT	Unknown		Low		Intermediate	X	High	
2	Geographical scale of impact	Unknown		Local		Regional		Global	X
3	Trans-boundary issues	Unknown		Low		Intermediate		High	X
4	Impact on ecosystems	Unknown		Low		Intermediate	X	High	
5	Impact on human health	Unknown	X	Low		Intermediate		High	
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown	X	Low		Intermediate		High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**3**		**0**		**3**		**2**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No		Partially	X	Completely	

Management options

There a number of regulations already in place to reduce the releases of debris into the seas and oceans. Role players are producers, consumers, regulatory authorities, and international organizations. Many regulations are in place in many parts of the world, especially dealing with waste disposal management, but there seems to be large gaps in many Developing Countries and CEIT. Internationally, the International Convention for the Prevention of Pollution from Ships MARPOL Annex V (covering garbage) is an optional annex and ratified by 116 countries but only covers ships in excess of 400 tons. Other MEAS in place are the London Convention, Basel Convention, Agenda 21 of the Johannesburg Plan of Implementation, the Jakarta Mandate of the Convention on Biological Diversity, and many others (UNEP, 2005). The UN General assembly has also taken note (UN, 2010).

Intervention need

The intervention need is seen as urgent. Interventions, such as prevention and cleanup are available and should be extended. However, the existing pollution is often in ABNJs, or near poor economies. Expanded international actions seem therefore warranted and urgent. Note must be taken that coastal communities may be heavily impacted, but overshadowed by other ECMIs inland.

Selected comments from respondents

- [Africa] Increased dumping of debris in water ways
- [Africa] A major issue in the country is related to marine debris which is related anthropogenic activities in land which pollute our oceans

Ammunition, propellants, military equipment, and the environmental chemical legacy of war and conflict

Description

The tragic immediate human and environmental consequences of warfare and conflict are easy to see and are dealt with by a number of UN agencies. The post-conflict/war chemical legacy of war and conflicts therefore falls within the scope of this report.

The declared world military spending in 2008 was $1.46 trillion, or $217 per person in the world. In contrast, all the UN agencies' and funds' spending was $27 billion, or $4 per person (Global Issues, 2009). It can also be safely assumed that much of the defense spending involves chemicals or ancillary activity in one form or another, including ammunition and equipment. It can also be assumed that many of these products are (were?) not designed with end-of-life concerns of recyclability and environmental safety uppermost in mind. Although many defense forces now have environmental management programs in place, the life cycle of unused and/or eventually obsolete/discarded munitions and other chemical containing equipment and infrastructure may lead to environmental pollution. Classic examples are PCBs associated with remote military installations, radium from disused aircraft instrument dials, and ammunition and chemical weapons discarded in marine waters. Even after intended use, depleted uranium, dioxins, and PCBs and PAHs following burning have raised concerns. This report will only consider conventional munitions, not chemical warfare agents.

Reasons for Developing Countries and CEIT concern

The whole life cycle of ammunition and other military equipment, from research and development, through manufacture to eventual use or disposal, has many opportunities for polluting the environment beyond the scope of their intended use. Much of the research and development and production part of the life cycle of ammunition remain mostly within the boundaries of individual states (both Developed Countries, Developing Countries, and CEIT). It may therefore be argued that it is mainly of local concern.

There are instances, however poorly characterized, that may have concerns within the transboundary mandate of GEF. Just as obsolete pesticides may accumulate in dumps in Developing Countries and CEIT, so can ammunition and obsolete military equipment sold or donated to poor states. If a small country such as Albania has an estimated 104 000 tons of surplus and obsolete ammunition (Wikipedia, 2009), and up to 100 000 tons in Afghanistan (Lauritzen et al. 2006) it is likely that the worldwide amount should be millions of tons. The laying of landmines could also be seen as 'dumping' apart from their explosive hazard. For example, for Bosnia and Herzegovina it was estimated that 2 000 km^2 of land was contaminated with 670 000 landmines and 650 000 pieces of unexploded ammunition (Fitzgerald, 2007).

These scenarios all have the potential to leach chemicals to the environment, especially in countries that do not have the facilities, knowledge, or finances to destroy or manage these dumps effectively. It may be a growing problem, given the current security situation.

Burning and destruction during the course of action can also cause pollution, as has been shown in the Balkans (Klanova et al. 2007) and during the Gulf War (Tazaki et al. 2004).

Releases

If releases during legitimate manufacture and proper storage of ammunition is considered as 'localized' potential for environmental contamination (Baretto-Rodrigues et al. 2009), then use during training, action, deployment (e.g. mines), decommissioning (also called demilitarization), dumping, or neglect can potentially contribute to environmental pollution that may be trans-boundary in nature.

Pollution

Pollution can be either from the explosives, primers, or propellants (such as rocket fuel), or from the casings (such as heavy metals) and other materials in equipment (mercury in switches, electronic equipment, etc), oils and lubricants, pesticides (e.g. malaria control), transformer oils, or a myriad of chemicals in many other applications. Depleted uranium from shells has been in the news as well (Bem and Bou-Rabee, 2004).

Pollution in war-contaminated areas may only become apparent after decades. Copper, lead and zinc are present at elevated levels in WW I battle fields, as are organic compounds such as arsenic, nitrobenzenes, notrotoluenes, nitrophenols, and triphenylarsine (Bausinger et al. 2007).

Much of the available information about environmental pollution comes from training and firing grounds, and may be applicable to war and conflict situations. Examples:

- Trinitrotoluene and other explosives have been detected in soil, water, air, sediment, and biota (ATSDR 1995; Clausen et al. 2004; Hewitt et al. 2005; Cruz-Uribe et al. 2007).
- Unexploded shells should be regarded as significant sources of explosives to ground water, as some of the chemicals they contain are highly mobile, especially in sandy soils (Lewis et al. 2009).
- High-yield artillery shells can deposit up to 2% of the TNT on the surrounding soil (Taylor et al. 2004). For low-yield explosions, much more remains unexploded on the ground, up to 37% of the original TNT in the shell.

This indicates that appreciable proportions of explosives remain in the areas of application, capable of causing localized high concentrations that could lead to exposure of biota and humans. Many explosives and other chemicals undergo biological or physical transformations, resulting in breakdown products that may also be toxic (Rosen and Lotufo 2007).

Exposure and uptake

Aquatic and soil organisms are probably the major exposed groups to chemicals associated with military chemicals, as shown by presence of these compounds in these media, as well as accumulation (Clausen et al. 2004; Hewitt et al. 2005; Cruz-Uribe et al. 2007; Rosen and Lotufo 2007). Humans are exposed via water, food (plants accumulate TNT from the soil), and contact with soil or surfaces that contain TNT, or via inhalation.

Marine mussels can accumulate explosives such as TNT to a small amount (bioconcentration factor (BCF) of 1.61), but not RDX or HMX (Rosen and Lotufo 2007). Channel catfish did not accumulate TNT, and broke it down rapidly to breakdown products that did appear to accumulate and may be transferred to higher trophic levels (Ownby et al. 2005). The exposure and uptake of military chemicals are now receiveing considerable attention by scientists, but very few of these studies have been conducted in Developing Countries and CEIT.

Impacts on ecosystems and human health

Much of the literature on ammunition refers to TNT. During World War I, about 475 US factory workers working with TNT died due to inhalation and dermal uptake (ATSDR 1995). Humans working with TNT have been seen with anemia, abnormal liver function, and cataracts after being exposed to TNT mainly via air. Workers in China showed signs of reduced semen volumes, effects on sperm motility, and sperm malformations (ATSDR 1995).

Bacterial communities in soils showed drastic changes in composition when exposed to leaching TNT (George et al. 2008). Marine mussel larvae showed sub-lethal effects when exposed to TNT, RDX and HMX (Rosen and Lotufo 2008). Several biomarkers in European eels were affected by TNT in water (Della Torre et al. 2008). Mortality and several sub-lethal effects were observed in lizards exposed orally to TNT (Mcfarland et al. 2008). Crustaceans and fish exposed in water to TNT buried in sediment showed high mortalities (Ek et al. 2008). No effects on rodent sperm parameters or liver mass from areas with burning pads (to destroy waste and explosives) were noted (Tannenbaum et al. 2003).

Disturbingly, it seems that there may be an increase in abortions associated with wars and conflict, and chemical exposure may be involved. Increased spontaneous abortions were noted in Bahrain and Kuwait, possibly associated with the oil fires (Rajab et al. 2000).

As with many other ECMIs, multiple exposures are very likely to follow conflict and war situations. Many of the studies only considered single chemicals, and more work needs to be done. Coupled with chemical exposure the stress associated with traumatic experiences (Pedersen 2002; Salvage 2007; Hynes 2004) may also affect the eventual effects of chemical exposure.

Nanotechnology may also be involved as it is likely that NPs will be used increasingly in equipment and ammunition, and also that explosions and fires also release NPs to the environment (Glenn 2006; Tazaki et al. 2004).

Poverty is more likely to be a consequence of war rather than a cause of war, although these relationships need further investigation (Goodhand 2003). Existing poverty and increased poverty may however, exacerbate exposure to chemicals, due to open living conditions, lack of treated water, and inability to move away from conflict zones.

Geographical scope and transboundary transport

Trade in ammunition and military equipment is a very effective method of global distribution prior to its use or becoming obsolete. Otherwise, very little is known about transboundary pollution of military chemicals. Dumping in marine waters (OSPAR 2006) and possibly in freshwater lakes and rivers has occurred as well, indicating the possibility of marine and fresh water transport across boundaries. Even transport by groundwater with a production plant as source (for more than 1 km) has been shown, although not across boundaries (Natif and Adar, 2005).

Some of the primary compounds and breakdown products would be volatile, although very little has been published in this regard. However, the fall-out from oil fires in Iraq during the Gulf War was detected in rain in Japan (Tazaki et al. 2004). Air quality was affected in Saudi Arabia due to the Gulf War (Husain 1998), and effects and pollution were seen in the coastal waters of the United Arab Emirates and Saudi Arabia (Banat et al. 1998; Vaquez et al. 2000). Transport via air of pollutants (including PCBs and dioxins) due to burning has also been seen in the Balkans (Klanova et al. 2007; Vukmirovic et al. 2001).

Lastly, it should be noted that many wars and conflicts occur near national boundaries and /or international waters.

Management options

A number of regional and global agreements and conventions address weapons, ammunition, conflict, and warfare, but none could be found that address the health and environmental effects due to chemical legacy.

Intervention need

Even with sparse evidence that the legacy of obsolete ammunition and warfare has significant environmental and human health effects (no comprehensive study could be found) it seems likely that there will be negative effects following conflict and war, and that there is potential for trans-boundary transfer of pollutants and effects.

Selected comments from respondents

- [Oceania] The presence of unexploded ordinance (UXO) from the Second World War is still a concern on some Pacific Islands. Other than that, the prevalence of ammunition use is relatively low.
- [Africa] Small scale ad hoc research project has been initiated in a very localised area. The - - - Programme is the generic management framework that may be able to accommodate management of this ECMI.
- [Africa] Guns, ammunition and fire arms are regulated but not on the environment aspect but rather on the dangerous?(firearm) aspect.
- [South America] These compounds are classified as governmental responsibility.
- [Africa] There are major issue related ammunition, military equipments and the environmental chemical legacy of war and conflict, this has pose certain risk to the local communities. It is a legacy of the WWII.

	ECMI Concern Criteria	Chemical legacy of war and conflict							
1	Concern to DC&CEIT	Unknown		Low		Intermediate	X	High	
2	Geographical scale of impact	Unknown		Local		Regional	X	Global	
3	Trans-boundary issues	Unknown		Low		Intermediate	X	High	
4	Impact on ecosystems	Unknown		Low		Intermediate	X	High	
5	Impact on human health	Unknown		Low		Intermediate	X	High	
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown		Low		Intermediate	X	High	
8	Intervention priority	None		Long-term		Intermediate		Immediate	X
	ECMI CONCERN PROFILE		**1**		**0**		**6**		**1**

9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No		Partially	X	Completely	

Mine wastes and drainage

Description

Mining for minerals and fuel has been associated with human development millions of years ago. A hematite mine in southern Africa dates back some 40 000 years. Copper mining and smelting began as early as 4300 BC, and mining for other metals, such as lead, and silver became common by 2500 BC (Cole, 1999). Significant energy resources such as coal and uranium, and metals such as aluminum, lead, and zinc, are all still mined today worldwide.

Reasons for Developing Countries and CEIT concern

It is likely that more and more mines will be operated in Developing Countries and CEIT, increasing the chemical impact of the wastes if not regulated and operated properly. Often these mines are located in natural areas that need additional consideration for protection. Some may be located close to urban areas, potentially exposing humans to wastes. Undersea mining, and mining in Areas Beyond national Jurisdiction (such as in the polar areas) may also pose significant threats to biodiversity in the global commons.

Releases

Mined wastes commonly contain waste rock, tailings (in the form of slurry, comprising of fine particles after minerals and coal have been washed), and smelting wastes (including slag and ash). Often dusts are generated during operation. Air pollution given rise by metal smelting also generates fine particles containing toxic metals and other air pollutants such as sulfur dioxide. In addition, acid mine drainage is also of great concern.

Pollution

Besides problems of land subsidence, tailings, smelting wastes and mine drainage often contain high concentrations of undesirable contaminants, according to the types of minerals mined. Drainage and eroded materials from some of the mines, e.g. lead/zinc mines often contain high concentrations of toxic metals including lead, zinc, arsenic, cadmium, etc. Coal mine drainage contains high sulfur content, and the runoff of water is polluted by sulfuric acid, after a seam is exposed to water and oxygen.

Exposure and uptake

Workers of mining and smelting industries and to a certain extent nearby residents are exposed to dust and air pollutants generated by different mining and smelting activities. The toxic metals contained in mine tailings and smelting wastes may escape to nearby agricultural and aquaculture farms and they will become more bioavailable (especially under acidic conditions) and taken up by crops and fish. Similarly, people living on or near polluted sites, or people near or depending on polluted streams are also likely to be impacted.

Impacts on ecosystems and human health

Hazards related to surface mining are mainly restricted to effects from blasting and operation of heavy equipment, whereas hazards related to underground mining include exposure to dust, methane gas and flood of the miners. Working with heavy equipment and machinery in a very confined space has made underground mining the most hazardous profession. Inhalation and absorption of toxic substances by workers occur through gaseous or particulate materials and fluids present or emanating from mine sites (Ng, 2002).

The emission of toxic metals from mining activities, e.g. copper smelting has resulted in "biological deserts" which have remained devoid of vegetation for over five decades (Brenner, 1999). Elevated metal levels have caused a decline or disappearance of indigenous plants and biodiversity (Bradshaw, 1993). Microbial activities and important biological processes such as nitrogen fixation (Smith, 1997), soil enzyme activity (Kuperman and Carrierro, 1997), and microbial biomass production (Rost et al., 2001) are adversely affected.

Toxic metals could enter food chains, by transferring from grasses to grazing animals, food crops or fish to human beings. The latter may impose health hazards if the crops/fish produced are constantly consumed over a long period of time (Ye et al., 2002). Itai-itai disease is a typical example due to cadmium poisoning characterized by abdominal pain, vomiting, and other unpleasant symptoms associated with the constant intake of cadmium from paddy rice irrigated by water contaminated by metal mine drainage enriched with cadmium in the upper Zintsu River, Japan (Montgomery, 2006).

Colliery spoil commonly contains significant quantities of pyrite (more than 1%) and will generate acid mine drainage through oxidation. The low pH levels (as low as 2-3) of the acid mine drainage will kill all aquatic organisms in the receiving waters. The use of strong acids to extract metals will impose adverse impacts on soil quality due to acid deposition, inducing and accelerating soil degradation, resulting in depletion of nutrients in cultivated soils, increasing bioavailability of toxic metals in contaminated soils, and accelerating aluminium transportation from low acid-buffering soils to other environmental phases (Bi et al., 2003; Larssen et al., 1999a; b). With surface mine drainage, the low acidity could be treated by lime, but underground mine drainage poses a more serious problem. Fine particles of mine waste and smelting waste will cause siltation in receiving water bodies, due to wind and water erosion (Bell, 2002).

Mining operations and the wastes produced will generate a vast amount of affected land, which can affect climate change and lower biodiversity. The toxic metals contained in mine wastes will also limit the survival and establishment of biota to certain tolerant populations/strains (both fauna and flora) (Bradshaw, 1993). Mines very often use chemicals for ore extraction such as surfactants and coagulants. These could contain alkylphenols and other organic compounds that have toxic properties.

During the drafting of the report, a sludge dam considered to have been safe collapsed in Hungary with devastating effect. It will perhaps take decades for the environment to recover. Sludge dam collapses are fortunately not that common, but they do occur.

Geographical scope and transboundary transport

Trans-boundary issues will involve international waters and air pollution (e.g. metal smelting). Most mining requires water, and proximity to water often implies polluting it as well, including international waters. Trading of rock fertilizer mixed with mine wastes (such as slag and ash) would also be a problem (e.g. Cd in fertilizers). Migratory birds visit cyanide slurry pumped on tailings dams of gold mines all over the world and may be killed or otherwise affected (Donato et al., 2007).

Management options

A large number of intervention and regulatory options are available. International agreements seem limited, although the International Cyanide Management Code (ICMI, 2010) for the gold mining industry, a voluntary agreement with companies, represents a possible management model.

Intervention need

Intervention is needed to reduce releases of toxic chemicals to the environment and to restore impacted areas (Wong, 2003). It is also essential to stop illegal trading of rock fertilizers which are mixed with mine wastes (see ECMI; Cd in fertilizers).

	ECMI Concern Criteria	**Mine wastes and drainage**							
1	Concern to DC&CEIT	Unknown		Low		Intermediate		High	X
2	Geographical scale of impact	Unknown		Local		Regional		Global	X
3	Trans-boundary issues	Unknown		Low		Intermediate	X	High	
4	Impact on ecosystems	Unknown		Low		Intermediate		High	X
5	Impact on human health	Unknown		Low		Intermediate	X	High	
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown		Low		Intermediate		High	X
8	Intervention priority	None		Long-term		Intermediate		Immediate	X
	ECMI CONCERN PROFILE		**1**		**0**		**2**		**5**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No		Partially	X	Completely	

Selected comments from respondents

- [Oceania] There are only a few mines within the Pacific Region, but most suffer from a relatively lax degree of environmental management and control. The mines are regulated to varying degrees, but performance criteria are relatively lax and monitoring and enforcement is weak.
- [Africa] No mines in my country.
- [Africa] This is a major issue at the moment. With mines in decommissioning phases the active removal of groundwater is not taking place anymore and AMD is starting to decant and flow into streams and rivers. As part of mining licenses and environmental management plans of gold and uranium mines they have to treat their drainage water. They then need to comply with existing guidelines or with special standards. Compliance monitoring as per license requirement and national monitoring programs in receiving water bodies.
- [Africa] Mined out areas not rehabilitated.
- [Africa] Mine waste is a problem and polluting water bodies in most mining communities. Most water bodies in the vicinity of mining operations are seriously polluted with heavy metals from these mine tailings as a result of acid mine drainage.
- [Africa] Increased mineral prospecting with low technology for refining
- [Africa] This is a new type of development in the country where its wastes is stored in a tailings dam. The issue with mining waste is not obvious at the moment since it just opened this year.

Sewage

Description

Sewage treatment is designed to remove organic matter, solids, nutrients, and disease-causing organisms from municipal wastewater before it discharges into rivers or coastal waters. Sewage sludge and sewage effluent are by-products of sewage treatment.

Reasons for Developing Countries and CEIT concern

Releases

Sewage sludge is dewatered, stabilized, and disposed of in landfills, in municipal dumps, at sea, by high-temperature incineration, or by pyrolysis. It is also commonly used for agricultural application as soil conditioner or fertilizer. The problem is becoming more serious, especially in countries experiencing rapid increases in population and industrialization, resulting in a large amount of sewage sludge generated from urban centers, which need proper disposal.

Sewage sludge contains organic matter, macro (carbon, hydrogen, nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur) and micronutrients (such as boron, manganese, copper, zinc, molybdenum) which are important for plant growth. However, some elements (such as copper, zinc, molybdenum, and chlorine) can be harmful to humans, plants, or animals if they are present above certain limits (Donahue et al., 1977). In fact, ten "heavy" or trace metals are regulated by the USEPA: arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc. In addition, sewage sludge also contains many toxic organic compounds (such as phenols, polychlorinated biphenyls, and many other compounds referred to in this report) (USEPA, 1982).

Sewage sludge is also enriched with microorganisms including pathogenic organisms that may cause a wide range of diseases (Girovich, 1996).

Pollution

If sewage sludge that has not been properly treated is released into the environment, problems may be caused by toxic components such as ammonia, phosphorous compounds, and nitrates.Sewage can also cause eutrophication and concomitant increase in biological oxygen demand of water bodies due to the high content of carbon, nitrogen, and phosphorus. Spread of diseases will impose a serious health risk if sewage is not properly treated before its application onto land or other means of disposal. Often, sewage is discharged into waters without proper treatment and can and does cause disease when coming into contact with humans.

Exposure and uptake

Some, but not all of the toxic components contained in sewage tend to persist in the environment upon their release into aquatic ecosystems and can be bio-magnified in food webs. Furthermore, sewage can also spread both pathogens and parasites via water and on land (Alexander, 1999). Long-term agricultural application of sewage sludge and the use of sewage effluent as irrigation water have resulted in the accumulation of toxic metals in agricultural soils, which are then transferred to plants. Sewage, especially raw sludge, commonly contains heavy metals such as arsenic, cadmium, lead, mercury, etc. that are toxic to plants, animals and humans and, therefore its agricultural application should be properly regulated and minimized where needed. Sewage also contains many organic pollutants.

Impacts on ecosystems and human health

Wastewater treatment systems are generally effective in reducing the levels of pathogenic organisms (USEPA, 1999). It has been noted that further treatment of the solids by means of aerobic digestion (USEPA, 1992), anaerobic digestion (Whitemore and Robertson, 1995), composting (Epstein, 1997), heat during (Brandon et al., 1977) and alkaline stabilization (Pedersen, 1981) can further disinfect and destroy pathogens. The entry of pathogens into the food chain is the major concern for the health of humans and animals and this will depend on the survival of pathogens in soil and plants. Fortunately, the soil environment is hostile to pathogens, as desiccation, rise in soil temperature, and soil acidity would adversely affect their survival (viruses: Gerba, 1983; bacteria: Kowal, 1982; parasites: Sepp, 1980). Most of the pathogens are retained in the upper layer of soil (5-15 cm), but due to the low survivability of these pathogens, the potential for surface water contamination is minimized (Epstein, 2002).

The uptake and accumulation of trace elements and heavy metals to plants after the application of sewage sludge or bio-solids to land has been extensively studied in the past three decades. In general, their uptake is governed by many soil and plant factors.

Plant uptake of these trace elements and heavy metals are also affected by plant species, individual trace elements/heavy metals, soil characteristics, and also properties of sewage sludge. Accumulation in plants largely depends on the species, cultivars, and organs within the plant. It has been observed that more trace elements (including heavy metals) are concentrated in the leaves rather than in the fruit or grain (Logan, 1997; O'Conner et al., 2001).

Becket et al. (1979) suggested that the organic matter in bio-solids is able to bind toxic metals, while McBride (1995) contended that as the organic matter decomposed, toxic metals will become more soluble and result in increased uptake by plant - "the sludge time bomb hypothesis". However, a number of scientists proved that this is not the case, e.g. Chang et al. (1997) demonstrated that the 'time bomb' was not evident by using a set of experimental data obtained from a 10-year field bio-solids application. Studies also indicated that there was little movement of heavy metals into the subsoil (below 30 cm) and, thereby reduces the potential for heavy metals to move through the soil into ground water (Dowdy et al., 1991; Williams et al., 1987).

In terms of organic compounds contained in bio-solids, the uptake by plants is minimal (organochlorine pesticides: Beall and Nash, 1971; PCBs: Fries, 1982; PAHs: Wild and Jones, 1992; PCDD/Fs: Jones and Sewart, 1997). These organic compounds may undergo different reactions and transformations in the soil. These include volatilization and photochemical degradation (after surface application), and chemical decomposition, adsorption on soil particles, biodegradation, or movement through the soil when bio-solids are added to the soil (Chaney et al., 1996; O'Connor, 1998). A review of remaining sludge treatment is presented by Xiaofei et al. (2012).

The release of toxic chemicals from sewage sludge and sewage effluent may affect the local fauna, flora, and microbial communities. Sludge or untreated sewage released into rivers and seas could contribute towards trans-boundary pollution.

Geographical scope and transboundary transport

The trade in sewage sludge containing toxic components, discharge of sewage effluent and runoff from soils applied with sewage sludge, and incineration of sewage sludge may contribute to cross-boundary issues. Releases of sewage into oceans can impact coral reefs and biodiversity. As mentioned under PPCPs, many pharmaceuticals and other common use chemicals also find their way into sewage, and from there into the environment.

Management options

A number of well-established technological and regulatory options are available.

Intervention need

Intervention is needed to regulate the use of sewage sludge, especially raw sludge, on agricultural land, as well as the trading of fertilizer and soil conditioner containing sewage sludge that has not been properly

	ECMI Concern Criteria	Sewage							
1	Concern to DC&CEIT	Unknown		Low		Intermediate	X	High	
2	Geographical scale of impact	Unknown		Local		Regional	X	Global	
3	Trans-boundary issues	Unknown		Low	X	Intermediate		High	
4	Impact on ecosystems	Unknown		Low		Intermediate	X	High	
5	Impact on human health	Unknown		Low		Intermediate	X	High	
6	Climate change impacts	Unknown	X	Low		Intermediate		High	
7	Economic/social interactions	Unknown	X	Low		Intermediate		High	
8	Intervention priority	None		Long-term	X	Intermediate		Immediate	
	ECMI CONCERN PROFILE		**2**		**2**		**4**		**0**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No	X	Partially		Completely	

processed. This is especially true in a number of countries which are under rapid development (experiencing rapid increases in population and industrialization), which generate a large amount of sewage sludge due to the construction of sewage treatment plants in urban centers. These countries are under pressure about the disposal of such a large volume of sewage sludge generated. Furthermore, land application seems to be a convenient outlet, especially in countries that possess active agricultural operations. Guidelines and regulations governing land application of sewage sludge in these countries, in order to protect environment and human health, are often lacking or not fully enforced,

Even in the USA, although the scientific community in general supports the USEPA regulations on land application of bio-solids, a vocal minority believes that the 503 rule is not adequately protective of human health and the environment. Nevertheless, the risk-based approach adopted by the USEPA provides opportunity regulations when better/updated scientific data become available (Epstein, 2002).

Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture for the protection of public health have been established by the World Health Organization (Mara and Cairncross, 1989).

Selected comments from respondents

- [Oceania] There are very few sewage treatment plants in the region and most are very basic plants that do not produce sludge, relying instead on systems such as ocean outfalls. Hence sewage sludge disposal is not a significant issue. It should be noted however, that wastewater treatment and disposal is considered to be one of the most significant environmental issues in the region because of the problems caused by current disposal systems, such as septic tanks and uncontrolled coastal discharges.
- [South America] There is not an efficient control by the governmental offices. Also, there is a lack of sensitivity in people for this problem.
- [South America] Since 80% of sewage runs free in - - -, their detrimental effects can be seen in the whole country.
- [Southern Africa] For the heavy metal aspect, sludge is regulated.
- [Southern Africa] There are regulations pertaining to disposal of waste (including sewage sludge, etc.) These are contained within license conditions but it is very unlikely that it is monitored or enforced.
- [Western Africa] Raw sewage is usually pumped into the sea and there is treatment facility.
- [Western Africa] Lack of interest in spending on sewage treatment. In most DC/CEIT sewage treatment facilities are neither non existing nor very few. Sewage treatment is not a priority of most DC/CEIT governments and as a result most water bodies are polluted liquid waste.
- [Africa] There is a major issue associate with the sewage sludge since we don’t have a sewage treatment plant in the country, therefore, raw waste is dump right into the rivers and oceans.

Open Burning - with emphasis on open burning of biomass

Description, properties, use

Open burning refers to the burning of any matter outdoors and the products of combustion resulting from the burning are emitted directly into the air. Traditionally, open burning has been accepted as a way to dispose of household and yard waste, agricultural residues, and land development debris. The types of air pollutants emitted and their adverse impacts depend on the types of waste materials combusted. Open burning of certain wastes which contain toxic substances, such as electronic waste (containing toxic metals and persistent organic pollutants are described in another section). This section will focus on the open burning of biomass.

Burning of biomass including the clearing of forest and shrub land for agricultural use, energy production for cooking, heating, and reducing the volume of crop residues after harvest. Wildfires (occurring naturally due to lightning or deliberately) are also important contributions to biomass burning.

There are different types of biomass burning. Wood burning in fireplaces, woodstoves, and even open areas are common in some countries. Prescribed burning is the use of fire as a management tool under specified conditions for burning a predetermined area, in order to accomplish planned land management objectives. This is commonly practiced in developed as well as developing countries, to sustain healthy woodland ecosystems and to reduce the risk of catastrophic wildfires (Weber et al., 1992). Open burning of crop residues is a significant type of biomass burning. Crop residues (after harvest) can be removed rapidly by open burning, which cut down transportation cost and storage space, before farmers start preparing for the next growing season. The ash generated could also be used as fertilizer. Wildfires refer to unplanned and uncontrolled fires.

Reasons for Developing Countries and CEIT concern

Releases

It has been estimated that about 3 billion tons of biomass materials are burned every year, with 90% of biomass events initiated by humans (Abelson, 1994). Biomass burning is, therefore, a significant global source of gaseous and particulate pollutants emitted to the atmospheric environment. About 110-178 tons of crop residues are burned in the field in China every year (between June to July, and November to December; Cao et al., 2006; Yan et al., 2006). It can be assumed that a large amount of crop residue is also burned in other agricultural countries.

Pollution

Biomass burning involves the combustion of living and dead materials in forests, yard waste, agricultural residues, and fuel wood. Major emissions include particulate matter (PM), carbon monoxide, hydrocarbons, and nitrogen oxides (Levine, 1999). Particulate matter also contains highly toxic compounds such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and polybrominated diphenyl ethers (PBDEs).

Uncontrolled open burning of biomass, forest fires, and municipal solid waste incineration are important sources of PCDD/Fs (Kouimtzis et al., 2002). According to an estimate made by the USEPA, the amount of PCDD/Fs emitted to the environment from forest fires is higher than other sources (such as industrial and backyard trash burning) (CCDACC, 2005). It has been estimated that PCDD/Fs emission from open burning of crop residues ranged from 1.38 - 1.52 kg I-TEQ/yr, contributing to about 10 - 20% of China's total emissions (Zhang et al., 2008).

Exposure and uptake

In terms of human health, the major exposure pathway to different pollutants generated by biomass burning is mainly through inhalation. Very small particulate matter are the most dangerous, as they can penetrate into our alveolar cells. Furthermore, different POPs associated with small particulates could further aggravate the harmful effects.

Impacts on ecosystems and human health

In terms of environmental effects, uncontrolled fires can destroy different ecosystems which will take a very long time to recover. Carbon dioxide is the main greenhouse gas associated with the combustion of biomass.

Human health effects due to different air pollutants are well documented. A series of significant health problems are associated with particulate matter in air including asthma, increase in respiratory symptoms (such as coughing and difficult or painful breathing), chronic bronchitis, decease in lung function and premature death (Brunekreef et al., 2005). PAHs comprise of a group of over 1000 different chemical compounds of which many are known to be carcinogenic, based on a study on the burning of different firewood species in Australia (Zou et al., 2003). Health effects from chronic, long-term exposure to PAHs may include cataracts, kidney and liver damage and jaundice (Xu et al., 2006). Short-term exposure to high levels of PCDD/Fs may result in skin lesions (such as chloracne and patchy darkening of the skin), and altered liver function; whereas long-term exposure is linked to impairment of the immune system, nervous system, endocrine system and reproductive functions (Gullett and Touati, 2003). It has been noted that exposure to low concentrations of PBDEs may result in irreparable damage to the nervous and reproductive systems (Costa et al., 2008).

Jacobs et al. (1997) reported an increase in bronchial asthma in children living close to rice fields during burning seasons. Studies showed that human exposures to wood smoke are associated with increased self-reporting of respiratory symptoms (Larson and Koening, 1994) and increased hospital emergency admissions for chronic obstructive pulmonary disease, bronchitis, asthma and chest pain (Mott et al., 2002). During the Indonesia forest fires of 1997, it was observed that hospital admissions rapidly increased in seven hospitals in Malaysia, with short-term increases in cardio-respiratory hospitalizations, particularly those with asthma (Mott et al., 2008).

Geographical scope and transboundary transport

Air pollution involved with biomass burning is a trans-boundary issue. Large-scale forest fires occurring in different countries (i.e. Australia, Indonesia, and USA) in the past few years seem to be an environmental concern. It was estimated that a total of 121 626 ha of forest and 731 ha of crops and horticulture were burned in the 1997 Indonesian forest fires destroying 2 - 3% of the total land area. The fires destroyed a large amount of rain forest, contributing to a significant release of greenhouse gases (Levine, 1999), in addition to causing serious regional health problem and economic loss (Stoner, 1998). Long-range transport of POPs generated should not be overlooked.

Management options

A number of options are available, but implementation on a large scale will be difficult due to many contributing factors.

Intervention need

Local, regional and possibly international intervention is required if open burning is to be reduced to an acceptable level.

	ECMI Concern Criteria	Open burning							
1	Concern to DC&CEIT	Unknown		Low		Intermediate	X	High	
2	Geographical scale of impact	Unknown		Local		Regional		Global	X
3	Trans-boundary issues	Unknown		Low		Intermediate		High	X
4	Impact on ecosystems	Unknown		Low		Intermediate	X	High	
5	Impact on human health	Unknown		Low		Intermediate	X	High	
6	Climate change impacts	Unknown		Low		Intermediate	X	High	
7	Economic/social interactions	Unknown		Low		Intermediate	X	High	
8	Intervention priority	None		Long-term		Intermediate	X	Immediate	
	ECMI CONCERN PROFILE		**0**		**0**		**6**		**2**

	ECMI Descriptive Criteria								
9	Scientific knowledge	None		Poor		Intermediate	X	High	
10	Management option(s) available	Unknown		None		Some	X	Adequate	
11	Addressed by MEAs	Unknown		No	X	Partially		Completely	

Selected comments from respondents

- [Oceania] Biomass burning is widespread throughout the region but difficult to control because much of it is regarded as customary practice.
- [North America] 18 millions of individuals are exposed to this source. More information is needed for the effects on mixtures. Also, more information is needed regarding exposure to soot due to the lipophilic characteristics of this material (in Spanish : hollín). The - - - Government is trying to use alternative methods for cooking.
- [South America] Bad agricultural practices; people in cities trend to burn the domestic wastes.
- [Asia] Tire burning as an alternate to fuel wood is a big problem causing soot in many small-scale industries.
- [South America] Burning of sugar-cane fields and deforestation plays a critical role here. There is some action in the richest part of the country like - - -, not in the other part, however.
- [Africa] Burning of sugarcane fields before harvest, although it is strictly prohibited by law.
- [Africa] Limited to very specific instances, e.g. inadequate incineration facilities at hospitals, etc. Not a national priority.
- [Africa] Slash and burn farming practice is prevalence in - - -. Use of biomass as source of household energy in - - -.
- [Africa] Open dump burning is a big problem in most DC/CEIT. It has been accepted as part of daily life. The burning of solid waste in open dumps is a major as most DC/CEIT do not sort out waste as result everything (plastics, e waste etc.) is burnt and releases heavy doses of PAHs. Regulation is very very weak.
- [Africa] regulation poorly managed
- [Africa] Persistent number of incidences and amount of GHG emitted

Emerging Chemical Management Issues "on the horizon"

During the drafting of this report a number of issues were noted that were deemed not yet sufficiently documented to motivate coverage, but should still be briefly mentioned for future reference and/or update. These are listed below in no particular order.

- **Surfactants and lubricants:** Compounds such as siloxanes and certain perfluoroalkynated compounds are getting more attention in the literature and from regulatory authorities (Howard & Muir, 2010; Lu et al., 2010; Warner et al., 2010).

- **Unrecognized uses:** The recent findings of Dechlorane in a number of media, as well as its seemingly continued production and use as a flame retardants indicates that even assumed that a chemical is regulated (in this case Dechlorane is the same as mirex, a current POP in the SC), unrecognized uses may still persist under names not previously associated with a recognized chemical. This may particularly affect Developing Countries and CEIT that often do not have the means to identify this chemical, either as a banned chemical in itself, or incorporated in a product (Hoh et al., 2006; Moller et al., 2010; Wang et al., 2010; Zhenh et al., 2010).

- **Unrecognized secondary sources:** Landfill sites are often repositories of waste. However, it should not be assumed that many of the chemicals in the sites remain captured. PFOS and associated perfluorinated chemicals and a number of other POPs (Weber et al., 2011), have been found outside landfills and in fish. Particularly in Developing Countries and CEIT, such sites will probably pose a secondary source of current and candidate POPs, as well as many other pollutants, for very long periods, probably for decades.

- **Unrecognized effects:** Recently, it has become clear that pollutants have effects beyond the classic injury, cancer, and death. More subtle effects have also become associated with chemicals. Aspects such as behavioral alterations such as homosexual behavior in birds (Frederick & Jayasena, 2011); changed parental care in animals (Kodavanti & Cursas-Collazo, 2010), and, until recently, unexplained kills of bees (Whitehorn, wt al., 2012). Association of chemicals with new and previously non-suspected outcomes such as obesity and diabetes may become more prevalent as more science develops more tools. Interactions between pathogens and diseases such as HIV with chemicals are also attracting attention, and may become a major issue for Developing Countries and CEIT. Interactions between climate change and chemicals may spring some surprises.

- Quite a number of chemicals have been identified by Muir & Howard (2006) and Howard & Muir 2010 that may turn out to be toxic, persistent, and bioacumulative. A surprising number of flame retardants are included in these lists. Other types of chemicals are plasticizers, hydraulic fluids, fragrances, and UV stabilizers. It is therefore likely that many more chemicals need scrutiny in the future.

- **Sucralose:** Sucralose is a sweetener used in cooking and beverages, seems to be very stable in the environment, but more research on possible effects are needed.

- **Interactions of chemicals with disasters:** Earthquakes, floods, tsunamis, droughts, accidents, epidemics, and other natural or anthropogenic mega-events may interact with chemicals or cause releases of chemicals in ways not yet anticipated or recognized.

- **Chemicals used in sealants and in mining:** Many chemicals and solvents are used in sealants and in mining processes that may have effects on the environment and on human health. Little is yet known about these compounds in Developing countries and CEIT, although much mining happens here.

- **New chemicals and alternatives to existing chemicals:** A study by Strempel et al. (In press) showed that that established chemicals, especially those of technical and economic importance, are often replaced by alternative chemicals that also have non-desirable environmental properties. The development of new chemical products, they found, have not yet been directed towards less persistent, bioaccumulative, and toxic chemicals, although the need for that has been obvious since the 1970s. It seems therefore that new and/or alternative products with less desirable environmental properties may still be with us for some time to come.

In addition to questions based on the eight ECMI criteria, the respondents were also asked, *"Are there other ECMI "on the horizon" for your country/ region beyond those listed?"* Of the 28 responses received, the majority indicated no other ECMIs in the future, or who reiterated ones already covered. Several mentioned Pesticides and one noted Mercury (both ruled out as ECMIs for this report). One respondent noted specific types of chemicals, even though a more generic ECMI already covered them, i.e. "organic contaminants produced in the hydrocarbons industry or from the burning of biomass like the dioxins." This report therefore covered all major ECMIs currently recognized. The next chapter explores the results of the survey of experts from Developing Countries and CEIT.

CHAPTER 6

ECMI priorities in developing countries and countries with economies in transition

Introduction

Chemical management issues that affect human health and the environment are often intricate and multi-faceted. It can have effects locally, regionally, or globally. Some ECMIs have multiple regional foci, while others appear to be generic worldwide. The ECMIs identified in this report spans a wide range of issues that are different but also overlap. Some ECMIs, such as heavy metals and PAHs, have been issues for many decades and seem to be increasing in extent. Then there are the new issues such as nanomaterials and PPCPs that are also receiving more attention, with 'issues on the horizon' that mat rise in prominence when more information becomes available. ECMIs often have multiple sources (such as industry, consumer waste, and burning) and multiple modifiers (such as economic development, trade, culture, geography, natural disasters, accidents, and climate change). At the same time, scientific knowledge remains at a premium for almost all ECMIs.

Assessment of ECMIs

Entrepreneurial inventiveness result in new products or uses, and scientific endeavor find more ways of investigating potential or actual health and environmental consequences of these and the more established issues. This duality is reflected in the ECMI concern profiles described in the previous chapter, and summarized in Table 6.1. This table represents the authors' assessment of each ECMI and is not meant to derive priorities. Priorities as per survey by experts from Developing Countries and CEIT will be addressed from Table 6.3 onwards.

In Table 6.1, each ECMI row should be read from left to right:

- A higher number in the left (Unknown/None) column indicates deficient information to derive a concern profile.
- In the next three columns (None/low, Intermediate, and High), the higher the values towards the right, the greater concern there should be for that ECMI relative to others distributed more towards the left in the same three columns.

Table 6.1 needs to be interpreted with care. Each score is the sum of occurrence of category assignation (i.e. number of "unknowns", "lows", "intermediates" or "highs") for the different criteria; therefore, the same score for different ECMIs in almost all cases reflect the scoring of different considerations. Hence, they cannot be directly compared as each ECMI has its own circumstances and state of knowledge, and the text and additional materials should be consulted for a greater understanding. Table 6.1 however, does show, however, some interesting patterns:

- The concern profiles of ECMIs that have been recognized for some time, such as PAHs and heavy metals, tend to be towards the higher end of the scale. On the other hand, the scores for some newer ECMIs, such as PPCPs, Endocrine disruption, and Nanoparticles and nanomaterials, tended towards the lower end of the scale, as scientific uncertainty and lack of intervention options are being strengthened.
- ECMIs that have concern profiles more towards the middle, such as Inorganic fertilizers, Cadmium in fertilizers, Food additives, and Sewage tend to be problems on a single or multiple regional scales, instead of a global issue. Any mitigation however, will most likely contribute towards protection of associated global ecosystems (such as international rivers and oceans).
- Some ECMIs are now issues mostly found in Developing Countries and CEIT, such as Arsenic, Lead in paint, Ammunition and conflict, Mine wastes and drainage, and Sewage. Developed Countries have mostly been able to deal with these issues, are actively managing them to various extents, or have only legacies remaining. In Developing Countries and CEIT however, they remain or are growing, and may pose an increasing threat to human health and environment.
- Then there are ECMIs that are currently recognized from research in Developed Countries, but will or may become a problem, if not already so, in Developing Countries and CEIT. Examples of these are Endocrine disruptors, Mixture effects, Nanoparticles and materials, Marine debris, and PPCPs. These invariably have high scores in the

TABLE 6.1. Summarized concern profiles for the ECMIs, as assigned by the authors in Chapter 5.

ECMI	Concern profiles			
	Unknown/None	None/Low	Intermediate	High
Compound/class				
PAHs	0	0	4	4
Arsenic	0	0	5	3
Bisphenol A	5	0	2	1
Alkylphenols	1	0	5	2
Phthlates	2	0	4	2
Organotins	1	1	5	1
Heavy metals	1	0	2	5
Nanoparticles/materials	7	0	1	0
Lead in paint	1	0	3	4
Inorganic fertilizer	0	4	4	0
Cadmium in fertilizer	0	3	5	0
PPCPs	6	0	1	2
Illicit drugs	5	0	3	0
Food additives/melamine	1	1	4	2
Effects				
Endocrine disruption	0	0	3	5
Chemical mixtures	2	0	4	2
Process				
E-waste	1	0	2	5
Marine debris	3	0	3	2
Ammunition/conflict	1	0	6	1
Mine waste and drainage	1	0	2	5
Sewage	2	2	4	0
Open burning of biomass	0	0	6	2

Unknown/none column in Table 6.1, but this does not mean that they are of less concern; rather, they have less scientific knowledge associated with them, even if some ECMIs such as PPCPs and Bisphenol A have been around for many decades. Indeed, with scientific advancement, the score distributions may move towards the right, requiring renewed attention.

- Interwoven between many of the ECMIs, is the theme that production, use, disposal, release, and exposure scenarios are often different when compared with the same ECMI in Developed Countries. Available research and monitoring procedures as well as solutions and management interventions may not always be directly applicable to Developing Countries and CEIT.

From the previous chapter it is clear that many of the ECMIs overlap. An attempt to visualize these interactions is given in Table 6.2. Some of the interactions are hypothetical and not yet presented in literature. The number of interactions per ECMI is summed in the Total column, and the sum of interactions ranked in the Rank column.

TABLE 6.2. Assessment of the interactions between the different ECMIs.

	PAHs	As	BPA	AlkPh	Phth	O-Tins	HM	NP/M	PbPnt	Fert	Cd/Frt	PPCP	Drugs	FoodA	EDCs	Mix	Ewaste	M Debr	Amm	MineW	Sew	Burn	**Total**	**Rank**
PAHs																							**7**	**7**
As																							**3**	**11**
BPA																							**9**	**7**
AlkPh																							**10**	**6**
Phth																							**8**	**6**
O-Tins																							**4**	**10**
HM																							**15**	**3**
NP/M																							**11**	**5**
PbPnt																							**4**	**10**
Fert																							**4**	**10**
Cd/Frt																							**6**	**8**
PPCP																							**9**	**7**
Drugs																							**6**	**8**
FoodA																							**5**	**9**
EDCs																							**19**	**2**
Mix																							**21**	**1**
Ewaste																							**11**	**5**
M Debr																							**12**	**4**
Amm																							**6**	**8**
MineW																							**3**	**11**
Sew																							**11**	**5**
Burn																							**5**	**9**

Scrutiny of the interactions between ECMIs in Table 6.2 reveals the following:

- The two effects ECMIs (Mixture effects and Endocrine disruption) were ranked the highest. This means that many ECMIs contributed to interactions. For Mixture effects, all ECMIs were involved. Any interventions taken on the interacting ECMIs will therefore probably also reduce the extent of the two Effects ECMIs.
- Heavy metals was the next ranked ECMI, with all process related ECMIs contributing. Process related interventions would most likely therefore have the greatest mitigating impact on Heavy metals.
- Marine debris ranked in position four, indicating the multiple causes, effects and processes that contribute.
- ECMIs such as Bisphenol A, Alkylphenols, Phthalates, Tributyltin, PBDEs, PPCPs, Illicit drugs, Food additives, Chemical mixtures, and E-waste all share Endocrine disruption and Mixture effects as endpoints.
- ECMIs, such as PAHs, Heavy metals, and Open burning are associated with combustion.
- Nanoparticles and materials, Lead in paints, Cadmium in fertilizers, E-waste, Ammunition and conflict, Mine wastes and drainage, Marine debris, Organotins, Mixture effects, and Sewage all have Heavy metals in common.
- ECMIs such as PAHs, Alkylphenols, Phthalates, Heavy metals, Nanoparticles and nanomaterials, Inorganic fertilizers, Marine debris, Mixtures effects, E-waste, and Mine wastes and drainage share (although not exclusively) commonalities with industrial and mining activities.
- ECMIs such as Endocrine disruption, Mixture effects, and Marine debris may already be significant in Developing Countries and CEIT, but lack of knowledge is probably the reason why it is not yet fully recognized.

Table 6.2 should be read in parallel when interpreting the prioritized ECMI discussions that follow.

Survey results: Prioritization of ECMIs

This section presents the results of the ranked priorities - firstly the overall ranking, based on the complete data set of responses, followed by breakdown by region to highlight regional priorities. As mentioned in the methodology section, the ECMI criteria were scored according to level of concern (i.e. unknown/none, low, intermediate, high) so that a rank could be calculated for each criterion. Aggregate concern for each ECMI was calculated by summing each criterion score for any given ECMI and ranked for Aggregate concern rank. Other data manipulations showed the same results. Ranking patterns was then explored within and between regions.

Initial assessment showed that Oceania, with only four respondents, had a ranking pattern different from the larger four regions. It must be acknowledged that small islands experience conditions that modify the way in which ECMI concern criteria are considered compared to the continental or larger country situation. Therefore, it was clear that preservation of regional prioritization would also be important to this study. Aggregate concern rankings, with and without Oceania, are provided in Table 6.3, and Oceania will be considered separately in Table 6.8. Please note that the top-ranked ECMI is indicated with 1 and the lowest with 22.

Also take note that with so much interlinked information provided in the tables, only an overview of the major features will be given. Further in-depth interpretation, especially when looking at a particular ECMI, needs to be made with cross referral to its text in Chapter 5 and other tables.

Overall ranking

Table 6.3 represents the ranked ECMI concern criteria and Aggregate concern ranking of ECMIs for the four large regions, as well as the Aggregate concern ranking of all five regions combined.

Heavy metals was considered as greatest concern of the 22 ECMIs investigated with top-ranking by respondents at the highest level of concern (1) for Concern to Developing countries and CEIT, Impact on human health, Climate change interactions, Intervention priority, and Geographical scale of impact. Heavy metals was ranked as the 2^nd^ highest priority for Impact on ecosystems, ranked 4^th^ for Transboundary issues, and 6^th^ for Economic and social interactions. Heavy metals was also considered as the ECMI with the best scientific foundation (1). Heavy metals was also the highest ranked when Oceania was included.

The second-highest ranked ECMI was PAHs, based mainly on high-ranked concern for Impact on ecosystems (1), Transboundary issues (2), Impact on human health (2), Economic and social interactions (2), Concern to Developing countries and CEIT (3), and Climate change interactions (3). Scientific foundation for ranking PAHs so high (3) was on knowledge from Developing Countries and CEIT; the respondents, therefore, based their rankings on region-specific knowledge. PAHs was also the 2^nd^ highest priority when Oceania was included.

The third-highest ranked ECMI was Mixture effects, based on high concerns due to Transboundary issues (1), Impact on ecosystems (3), Economic and social interactions (3), Impact on human health (4), and Climate change interactions (4). Scientific foundation from Developing Countries and CEIT was low at rank 12; respondents therefore based their assessment on knowledge from elsewhere. With Oceania included, Mixture effects dropped to Rank 4 on Aggregate concern ranking.

The fourth-ranked ECMI was Open burning due to high concern for Economic and social interactions (1), Intervention priority (2), and Geographical scale of impact (2). Scientific foundation for this assessment was ranked at 8, indicating some knowledge from Developing Countries and CEIT, but more likely from elsewhere as well. With the scores from Oceania included with the other regions, Open burning increased in Aggregate concern ranking to 3^rd^ position because Open burning was the highest Aggregate concern ECMI for Oceania (Table 6.8).

The fifth-ranked Aggregate concern was Endocrine disruption, based on concerns for Impact on human health (2), Transboundary issues (3), and Impact on ecosystems (4). Scientific support for Endocrine disruption was considered lacking (ranked 10^th^), especially due to limited data from Developing Countries and CEIT. However, the respondents considered this ECMI to be of high concern based on information and assessments from elsewhere. With Oceania included, Endocrine disruption dropped to 6^th^ position on Aggregate rank.

Sewage ranked on aggregate at position 6. Interestingly, it was considered as the 2^nd^ highest ranked concern for Developing countries and CEIT, and ranked 4^th^ on Economic and social interactions. Scientific foundation for this assessment was ranked high at 4, indicating good knowledge from Developing countries and CEIT.

Ranked in 7^th^ and 8^th^ positions on aggregate were Inorganic fertilizers and Arsenic, respectively.

Inorganic fertilizer reached 7th position due to Intervention priority (3), Concern to Developing countries and CEIT (4), and Economic and social interactions. Arsenic, interestingly, scored 2nd rank for Climate change interactions, probably due to concerns about changes in ground water tables. Even more remarkable, Arsenic was ranked 2nd on Climate change interactions in Central and South America (Table 6.4), Africa (Table 6.5), Asia (Table 6.6), Eastern Europe (Table 6.7), and Oceania (Table

TABLE 6.3. Ranked concern and descriptive criteria for Developing Countries and CEIT for the 22 ECMIs as rated by the surveyed respondents from the four larger regions (Central & South America, Africa, Asia, and Eastern Europe). Two aggregate ranks are shown; one without and one with Oceania included. The highest ranked ECMI is 1, and the lowest 22. A separate ranking for Oceania is provided in Table 6.8.

ECMI	Concern to DC&CEIT	Trans-boundary issues	Impact on ecosystems	Impact on human health	Climate change interactions	Economic/social interactions	Intervention priority	Geographical scale of impact	**Aggregate concern rank - Oceania**	**Aggregate concern rank + Oceania**	High scientific confidence	Management options available*	Addressed by MEAs*
Heavy metals	1	4	2	1	1	6	1	1	**1**	**1**	1	L	P
PAHs	3	2	1	3	3	2	11	13	**2**	**2**	3	Y	P
Mixture effects	8	1	3	4	4	3	7	10	**3**	**4**	12	N	P
Open burning	5	7	8	5	10	1	2	2	**4**	**3**	8	L	P
Endocrine disruption	10	3	4	2	5	10	12	8	**5**	**6**	10	?	P
Sewage	2	10	18	6	9	5	6	4	**6**	**5**	4	Y	N
Inorganic fertilizer	4	8	7	9	17	4	3	6	**7**	**7**	6	Y	?
Arsenic	6	18	15	8	2	14	9	12	**8**	**9**	2	L	N
E-waste	7	5	5	12	16	8	5	15	**9**	**8**	21	Y	P
PPCPs	12	6	6	11	15	11	8	14	**10**	**11**	15	?	P
Mine waste	11	15	17	7	12	7	4	9	**11**	**10**	7	L	N
Lead in paints	9	12	14	14	6	15	14	11	**12**	**13**	4	Y	?
Illicit drugs	14	9	9	19	7	17	10	3	**13**	**14**	12	?	N
Cadmium in fertilizer	13	17	12	10	11	9	15	5	**14**	**12**	9	Y	?
Food additives	15	11	11	20	8	21	13	7	**15**	**16**	19	Y	P
Phthalates	16	13	10	16	13	16	19	16	**16**	**17**	18	Y	N
Bisphenol A	18	16	20	17	14	19	18	18	**17**	**19**	15	Y	N
Organotins	17	20	16	15	18	18	20	17	**18**	**18**	12	Y	P
Marine debris	20	14	13	13	21	12	17	20	**19**	**15**	22	L	N
Alkylphenols	19	21	19	18	19	20	22	22	**20**	**21**	19	Y	N
Ammunition/conflict	22	22	22	21	20	13	16	21	**21**	**20**	21	L	N
Nanoparticle/material	21	19	21	22	22	22	21	19	**22**	**22**	17	?	?

N= None; Y=yes; N=No; L=Little; P=Partially; ?=Unknown

**This data is derived by the assessment of ECMIs by expert authors and not the by the respondents. However they are included here as they offer additional insight.*

6.8). This high ranking was probably due to concerns about impacts on ground water that can be affected by climate change.

Although ranked in 13th position on Aggregate, Illicit drugs scored the 3rd rank on Geographical scale of impact. It is not clear why respondents had so much concern on this criterion, but it could be due to large catchments of rivers where drugs are grown and processed in sensitive upper reaches, and process (such as solvents) and drug residues transported downstream. Illicit drugs also scored higher (9) on Transboundary issues than Sewage (10).

At the lower end of overall concern were Nanoparticles and nanomaterials (22), Ammunition and conflict (21), Alkylphenols (20), Marine debris at 19, and Organotins at 18. As with any of the ECMIs, new information may shift the rankings. However, during calculations of the rankings, it became clear the higher ranked ECMIs were much more robust in maintaining that ranked positions than the lower ranked ECMIs.

A closer look at Intervention priorities

Intervention priority ranking did not reflect the same order as for Aggregate ranking. Heavy metals was top-ranked on Aggregate and Intervention priority. Open burning was ranked as the 2nd highest Intervention priority, but 4th on Aggregate concern. The respondents also clearly linked the source (Open burning) with one of its major emissions (PAHs) ranked in 2nd place on Aggregate, but 11th on Intervention priority, signaling that a reduction in Open burning would result in a reduction in PAHs.

The 3rd ranked Intervention priority was Inorganic fertilizer although it was ranked 7th on Aggregate. Inorganic fertilizer had appreciable ranks for Economic and social interaction and the general Concern to Developing countries and CEIT (both ranked at 4), but lower on other criteria. The issues and concerns about Inorganic fertilizer seems therefore different from the higher ranked ECMIs.

Although not ranking higher than 7 on any other concern criteria, Mining waste was ranked 4th on Intervention priority. The reasons for this high score is probably not captured by the concern criteria used here, but as an ECMI it clearly represents an issue that has a big impact and needs more scrutiny.

E-waste may have a high (5) Intervention priority due to the attention it is getting on platforms such as SAICM. However, another SAICM issue, Lead in paints, was ranked at 14 for Intervention priority and 12 on Aggregate concern. Based on the concern criteria, therefore, the respondents from the regions considered E-waste to be a much greater Intervention priority than Lead in paints. However, priorities in specific countries may differ and these rankings should be applied with local considerations in mind.

Descriptive criteria

Of the 135 respondents, 50 did enter their assessments for Scientific knowledge from Developing countries and CEIT. This was judged enough for an overall ranking but not for the regional breakdown. The High confidence ranking is provided in the summary Table 6.3, and a more detailed assessment accompanies Table 6.10. It is clear that Heavy metals has the best Scientific confidence rating based on science from Developing Countries and CEIT. Good scientific knowledge was also available for Arsenic, PAHs, Lead in paints, Sewage, and Inorganic fertilizer. High Aggregate concern ECMIs that took their scientific foundation for high rankings from Developed Country scientific output were Mixture effects (12), Open burning (8), Endocrine disruption (10), E-waste (21), PPCPs (15), and Mine waste (7). Respondents therefore, being members of SETAC, benefitted form international exposure.

Respondents, being mainly from academia, were less confident on Management options and MEAs as these aspects were mostly outside their scope of expertise. Few provided any information on this question. The information given in Table 6.3 was by the authors of this report with some outside inputs. Since so few responses were received on the descriptive criteria, these were not broken down for the different regions, but only considered on an overall level.

Management options in one form or another are available for some of the high-ranked ECMIs, such as for PAHs, Heavy metals, and Open burning. For Mixture effects and Endocrine disruption, there may be benefit from strengthening some existing management options such as improved waste and sewage management, but specific options to address these issues need to be better formulated.

Heavy metals, PAHs, Endocrine disruption, Open Burning, and Sewage all have some representation in one or more MEAs, but none are completely covered. It is worth keeping in mind that some MEAS are only active in more developed regions and that some endocrine disruptive compounds and some compounds included in Mixture effects are de facto regulated by some of the larger MEAs. It would perhaps be more instructive to look at those ECMIs least controlled by MEAs. Bisphenol A, Alkylphenols, Ammunition and conflict, Nanoparticles and materials, Food additives, PPCPs, and Phthalates are some ECMIs not addressed.

Regional breakdown of results

Central and South America

In Central and South America (Table 6.4), Heavy metals was ranked 1st on Aggregate concern due to Concern to Developing countries and CEIT (1), Impact on human health (1), Climate change interactions (1), Intervention priority (1), and Geographical scale of impact (1). The concern about heavy metal impacts on the ecosystem was comparatively low in 5th rank.

Mixture effects was ranked on aggregate as the 2nd greatest concern for Central and South America supported by the highest concern rankings (1) for Transboundary issues and Impact on ecosystems. Impact on human health, Concern to Developing countries and CEIT, and Intervention priority was ranked 2nd as concern criteria for Mixture effects.

TABLE 6.4. Ranked concern criteria for 22 ECMIs in Central and South America, rated by 41 respondents.

ECMI	Concern to DC&CEIT	Trans-boundary issues	Impact on ecosystems	Impact on human health	Climate change interactions	Economic/social interactions	Intervention priority	Geographical scale of impact	**Aggregate concern rank**
Heavy metals	1	4	5	1	1	6	1	1	**1**
Mixture effects	2	1	1	2	5	4	2	3	**2**
PAHs	4	2	2	3	5	2	9	5	**3**
Endocrine disruption	6	2	4	3	4	8	7	10	**4**
Open burning	11	10	7	9	11	1	3	2	**5**
Sewage	3	9	13	8	8	3	7	3	**6**
PPCPs	12	5	3	7	9	9	5	13	**7**
Inorganic fertilizer	5	7	8	5	15	5	10	12	**8**
Illicit drugs	8	8	5	16	3	11	13	5	**9**
Arsenic	7	15	16	10	2	15	5	8	**10**
Mine waste	10	13	14	6	11	7	4	9	**11**
Cadmium in fertilizer	13	11	12	11	10	10	12	11	**12**
E-waste	8	6	10	12	14	12	11	14	**13**
Marine debris	14	17	9	13	20	12	14	17	**14**
Food additives	18	13	10	20	13	21	15	7	**15**
Phthalates	15	12	15	14	15	19	17	18	**16**
Lead in paints	15	16	19	19	7	17	15	16	**17**
Organotins	15	21	18	15	18	16	21	15	**18**
Bisphenol A	20	18	19	17	17	17	20	20	**19**
Alkylphenols	19	20	17	18	19	20	22	19	**20**
Nanoparticle/material	21	19	21	22	22	22	18	20	**21**
Ammunition/conflict	22	22	22	21	21	14	19	22	**22**

PAHs was ranked 3rd due to high rankings from Transboundary issues (2), Impact on ecosystems (2), Economic and social interactions (2), and Impact on human health (3).

Fourth-highest ranked on Aggregate concern was Endocrine disruption, surprisingly because of concerns with Transboundary issues (2), but also about Impact on human health (3), Impact on ecosystems (4), and Climate change interactions 4). The high ranking for Transboundary issues may be driven by the many internationally shared catchments and rivers in this region.

The top rank (1) for Economic and social interactions, supported by concerns about Geographical scale of impact (2) and Intervention priority (3), pushed Open burning into 5th rank on Aggregate concern. Note that PAHs at Aggregate rank 3 had an intervention priority of 9. The respondents clearly associated Open burning and PAHs and indicated that reduction of the cause (Open burning) would to some extent take care of the PAHs.

Sewage was ranked 6th on Aggregate based on 3rd highest ranking for Concern to Developing Countries and CEIT, Economic and social interactions, and Geographical scale of impact. Impact on ecosystems was ranked comparatively low (13) for this ECMI. However, Impact on ecosystems by PPCPs was ranked 3rd, making PPCPs the 7th ranked on Aggregate. Given the close association between Sewage as a significant source of PPCPs, this link seems an obvious target for intervention.

Other ECMIs to take note of are:

- Arsenic, based on a high ranking for Climate change interventions (2), came in 10th on Aggregate concern. This is in line with Arsenic rankings in the other regions.
- Illicit drugs, ranked 9th on Aggregate concern, has a connection with Climate change (3) in Central and South America. The connection with Climate change is not quite clear.
- Mine waste had a high intervention priority of 4, indicating serious problems with this ECMI in the region. With a ranking of 9 on Geographical scale if impact, and 13 for Transboundary issues, it seems that impact is restricted to certain areas, but that its effects are of serious concerns.

Lowest ranked ECMIs were Ammunition and conflict (22), Nanoparticles and products (21), Alkylphenols (20), and BPA (19).

Intervention priorities were Heavy metals (1), Open burning (2), Mixture effects (2), Open burning (3), Mine waste (4), PPCPs (5), and Arsenic (5).

Africa

The highest-ranked Aggregate ECMI in Africa (Table 6.5) was Heavy metals due to having the highest concern rankings (1) for Impact on ecosystems, Climate change interactions, and Geographical scale of impact. Further supporting Heavy metals in the top rand was concern expressed about Intervention priority (2), Transboundary issues (2), and Concern to Developing Countries and CEIT (2). Impact on human health, that ranked 1 in Central and South America for Heavy metals (Table 6.4), was ranked in 6th position in Africa.

Second-highest Aggregate ranking ECMI was PAHs, driven by concerns for Human Health (1), Impact on ecosystems (2), Economic and social interactions (2), and Climate change interactions (3). Respondents probably were considering human exposure to PAHs from burning for heating and cooking when ranking this ECMI so high for Impact on human health.

The third-highest aggregate ranking was for E-waste based on concerns for Transboundary issues (1),

TABLE 6.5. Ranked concern criteria for 22 ECMIs in Africa as rated by 44 respondents.

ECMI	Concern to DC&CEIT	Trans-boundary issues	Impact on ecosystems	Impact on human health	Climate change interactions	Economic/social interactions	Intervention priority	Geographical scale of impact	**Aggregate concern rank**
Heavy metals	2	2	1	6	1	6	2	1	**1**
PAHs	4	8	2	1	3	2	8	6	**2**
E-waste	7	1	3	6	6	4	1	9	**3**
Lead in paints	3	6	4	3	5	11	5	3	**4**
Open burning	6	12	10	5	8	1	3	3	**5**
Illicit drugs	7	3	4	14	4	18	4	3	**6**
Mixture effects	11	9	4	3	7	3	8	8	**7**
PPCPs	9	5	7	10	11	9	10	7	**8**
Inorganic fertilizer	1	14	9	13	19	6	6	15	**9**
Sewage	5	10	17	2	10	8	6	10	**10**
Arsenic	12	11	14	6	2	15	11	14	**11**
Endocrine disruption	15	7	7	9	8	13	12	10	**12**
Food additives	13	4	11	15	13	18	14	2	**13**
Mine waste	14	13	15	11	11	11	13	12	**14**
Cadmium in fertilizer	10	19	13	11	15	14	15	12	**15**
Ammunition/conflict	20	15	20	20	16	5	15	18	**16**
Phthalates	16	20	15	18	13	16	21	17	**17**
Alkylphenols	16	18	11	20	18	16	19	19	**18**
Marine debris	19	16	20	16	22	10	17	21	**19**
Bisphenol A	21	17	18	19	16	21	19	16	**20**
Organotins	18	22	18	17	20	20	18	22	**21**
Nanoparticle/material	22	20	22	22	21	22	22	20	**22**

Intervention priority (1), Impact on ecosystems (3), and Economic and social interactions (4).

Lead in paints was ranked 4th on Aggregate concern, due to Geographical scale of Impact (3), Impact on human health (3), Concern to Developing Countries and CEIT (3), and Impact on ecosystems (4).

E-waste and Lead in paints was ranked higher in Africa than in any other region. This might be due to the high public profile of these ECMIs. When compared to Asia, where E-waste is also a current issue, E-waste ranked 7 and Lead in paints ranked 8 (Table 6.6). In both regions therefore, these two issues ranked relatively high, emphasizing its importance.

Open burning was ranked 5th on Aggregate concern due to Economic and social interactions (1), Intervention priority (3), Geographical scale of impact, and Impact on human health (5). The strong association with economic and social concerns, combined with the high Aggregate rank for PAHs (2), indicates an overall need for intervention.

Ranked in 6th position on Aggregate concern was Illicit drugs. Respondents were concerned here about Transboundary issues (3), Geographical scale of impact (3), Impact on ecosystems (4), Intervention priority (4), and Climate change interactions (4). The link between Illicit drugs and Climate change is not clear. However, in Central and South America, Illicit drugs that was ranked in 9th position on Aggregate concern, also had a relatively strong association with Climate change interactions in 3rd position (Table 6.4).

Different from the other regions except Oceania, African respondents ranked both Mixture effects and Endocrine disruption relatively low in 7th and 12th position on Aggregate rank. This might be due to lack of empirical knowledge from this region, or the relatively higher priority given to issues such as heavy metals and PAHs. Respondents probably indicated here that intervening in these two compound-based ECMIs would reduce overall toxic stress.

Other ECMIs to take note of are:

- Arsenic that ranked 2nd on Climate change interactions (probably due to concerns about changes in water tables),
- Inorganic fertilizer that ranked 1st on Concern to Developing countries and CEIT (possibly due to land degradation),
- Food additives that ranked 2nd based on Geographical scale of impact (possibly due to lack of quality control effectiveness),
- Ammunition and conflict that ranked 5th concerns about Economic and social interactions, and
- Sewage that ranked 2nd on Impact on human health.

Lowest-ranked overall concerns for Africa were Nanoparticles and nanomaterials (22), Organotins (21), BPA (20), Marine debris (19), and Alkylphenols (18).

Intervention priorities were E-waste (1), Heavy metals (2), Open burning (3), Illicit drugs (4), Lead in paints (5), and Inorganic fertilizer and Sewage in joint 6th position.

Asia

The highest-ranked ECMI on Aggregate in Asia (Table 6.6) was Heavy metals due to top rankings (1) for Impact on ecosystems, Climate change interactions, Intervention priority and Geographical scale of impact. Additional concerns came from Impact on human health (2), Concern to Developing countries and CEIT (2), and economic and social interactions (3).

Second-highest ranked ECMI for Asia was PAHs supported by highest ranking (1) for Impact on human health and Transboundary issues, but also by high-ranked concerns (2) for Impact on ecosystems, Climate change interactions, and Economic and social interactions.

Open burning was ranked 3rd on Aggregate due to concerns about Economic and social interactions (1), Intervention priority (2), and Geographical scale of impact (2). Impact on Human health and Impact on ecosystems were both ranked in 4th position for

TABLE 6.6. Ranked concern criteria for Asia for the 22 ECMIs as rated by 27 respondents.

ECMI	Concern to DC&CEIT	Trans-boundary issues	Impact on ecosystems	Impact on human health	Climate change interactions	Economic/social interactions	Intervention priority	Geographical scale of impact	**Aggregate concern rank**
Heavy metals	2	7	1	2	1	3	1	1	**1**
PAHs	4	1	2	1	2	2	14	18	**2**
Open burning	5	9	4	4	17	1	2	2	**3**
Endocrine disruption	8	2	3	3	4	6	11	12	**4**
Arsenic	1	15	7	5	2	15	5	7	**5**
Mixture effects	10	2	5	6	5	3	5	12	**6**
E-waste	3	4	6	13	13	12	3	7	**7**
Lead in paints	7	6	8	11	8	13	11	6	**8**
Bisphenol A	9	5	8	7	7	16	8	14	**9**
Cadmium in fertilizer	12	11	11	10	9	8	18	3	**10**
Mine waste	11	11	17	7	10	9	7	9	**11**
Sewage	5	15	19	9	13	6	13	16	**12**
Inorganic fertilizer	16	18	12	13	13	3	4	5	**13**
Food additives	12	18	16	19	6	22	9	9	**14**
PPCPs	18	8	15	17	18	13	9	9	**15**
Phthalates	15	11	17	16	11	16	16	14	**16**
Organotins	12	9	12	12	16	18	22	19	**17**
Illicit drugs	19	20	14	20	12	18	16	4	**18**
Marine debris	20	15	8	13	21	18	15	16	**19**
Alkylphenols	17	11	21	17	19	18	20	21	**20**
Nanoparticle/material	21	20	20	22	22	9	20	19	**21**
Ammunition/conflict	22	22	22	21	20	11	19	22	**22**

this ECMI. That PAHs ranked 2nd, and Open burning ranked 3rd in Asia, emphasizes the scope of the problem this continent faces. Interventions that would address these two ECMIs together would significantly diminish their combined impacts.

Endocrine disruption was ranked 4th on Aggregate concern based on concern criteria rankings for Transboundary issues (2), Impact on ecosystems (3), Impact on human health (3), and Climate change interactions (4). The reason for the association between climate change and endocrine disruption is not quite clear, but may have to do with changing production, use, and emission patterns of chemicals.

Ranked 5th on Aggregate concern, Arsenic had Concern about Developing Countries and CEIT (1), but ranked 7th for Geographical scale of impact and 15th for transboundary issues. This indicates that the Arsenic as ECMI has geographic foci of impact but also that it affects the region as a whole. Arsenic also ranked 2nd for Climate change interactions, most likely due to changes in ground water. Arsenic in Asia attained its highest Aggregate ranked position for any region. This also suggests that sub-regional rankings may be necessary, as Asia is a large continent, most likely with geographically distinct ECMI priorities.

Mixture effects ranked 6th on Aggregate concern, based mainly on Transboundary issues (shared 2nd rank with Endocrine disruption), Economic and social interactions (3), Impact on ecosystems (5), Climate change interactions (5), and Intervention priority (5).

E-waste was ranked in 7th position on Aggregate concern. Intervention priority was high at 3, as well as Concern to Developing Countries and CEIT (3), and Transboundary issues.

Other ECMIs to take note of are:

- Lead in paints were ranked 6th for both Transboundary issues (probably related to trade) and Geographical scale of impact.
- Inorganic fertilizer ranked 3rd, 4th, and 5th for Economic and social interactions, Intervention priority, and Geographical scale of impact, respectively.
- Illicit drugs only received a good ranking (4) for Geographical scale of impact – the rest of the concern criteria were ranked 12 or less.
- Given that Food additives was such a major news item recently, it is surprising that it its highest rank was for Climate change interactions (6). It ranked 19th for human health, but at least 9th for intervention priority, giving an Aggregate concern rank of 14.
- Based on the respondents feedback, Sewage was ranked on Aggregate concern in 12th position. It may be that Sewage was discounted by the relatively high Aggregate rankings for Endocrine disruption (4) and Mixture effects (6).

Overall, the lowest-ranked ECMIs in Asia were for Ammunition and conflict (22), Nanoparticles and materials (21), Alkylphenols (20), and Marine debris (19).

Intervention priorities were Heavy metals (1), Open burning (2), E-waste (3), Inorganic fertilizers (4), and Mixture effects and Arsenic in joint 5th position.

Eastern Europe

In Eastern Europe, the highest-ranked ECMI on Aggregate concern was Heavy metals (Table 6.7). Top ranking was due to Geographical scale of impact (2), Impact on human health (2), Transboundary issues (20, and Concern to Developing countries and CEIT (2).

Mixture effects was ranked 2nd on Aggregate concern as Transboundary issues, Impact on ecosystems and Impact on human health concern criteria were ranked in position 1. Interestingly, Climate change interactions was ranked in 2nd position for Mixture effects, but was ranked in 16th position for Geographical scale of impact.

Ranked in 3rd and 4th position on Aggregate concerns were Open burning and PAHs, respectively. Economic and social interactions (1) and Geographical scale of impact (2) were the highest ranked concern criteria for Open burning. Climate change interactions (10, Impact on ecosystems (3), Transboundary issues

TABLE 6.7. Ranked concern criteria for Eastern Europe for 22 ECMIs rated by 18 respondents.

ECMI	Concern to DC&CEIT	Trans-boundary issues	Impact on ecosystems	Impact on human health	Climate change interactions	Economic/social interactions	Intervention priority	Geographical scale of impact	**Aggregate concern rank**
Heavy metals	2	2	6	2	4	7	4	2	**1**
Mixture effects	7	1	1	1	2	4	8	16	**2**
Open burning	5	5	11	6	6	1	6	2	**3**
PAHs	3	3	3	8	1	2	9	18	**4**
Inorganic fertilizer	3	5	4	4	20	3	2	2	**5**
Sewage	1	7	18	6	9	5	2	1	**6**
Endocrine disruption	10	3	2	3	5	12	12	5	**7**
Mine waste	6	18	20	5	16	6	1	8	**8**
Phthalates	12	8	4	10	6	13	18	14	**9**
Arsenic	7	22	20	8	2	10	12	11	**10**
PPCPs	10	10	8	16	12	15	6	11	**11**
Organotins	15	10	10	11	12	16	16	14	**12**
Food additives	16	8	11	21	8	13	9	11	**13**
E-waste	12	10	7	17	21	10	9	20	**14**
Lead in paints	7	16	13	14	12	21	18	9	**15**
Cadmium in fertilizer	18	20	20	13	12	8	17	7	**16**
Nanoparticle/material	14	10	9	20	17	16	15	10	**17**
Ammunition/conflict	16	18	13	19	17	16	12	16	**18**
Illicit drugs	22	15	18	22	17	22	4	5	**19**
Bisphenol A	20	16	16	18	10	16	20	19	**20**
Alkylphenols	20	20	13	14	11	16	20	21	**21**
Marine debris	19	10	16	11	22	9	22	22	**21**

(3) and Concern to Developing countries and CEIT influenced the ranking for PAHs. Where Open burning ranked 2nd on Geographical scale of impact, PAHs ranked in 18th place. Although Open burning is not the only source of PAHs, the respondents clearly linked these two ECMIs.

Inorganic fertilizer ranked in 5th position on Aggregate concern, the highest ranked this ECMI achieved in any region. The major concern drivers in Eastern Europe for Inorganic fertilizers were Geographical scale of impact (2), Intervention priority (2), Economic and social interactions (3), Concern to Developing Countries and CEIT (3), and Impact on ecosystems (4), Impact on human health (4). For the four larger regions, these concern criteria ranked the highest for Inorganic fertilizer in Eastern Europe. Presuming that Eastern Europe is further along the development trajectory, it may signal that Inorganic fertilizer may become an increasing problem in the other regions when they develop further.

Sewage was ranked in 6th position on Aggregate concern (same as Central and South America) with a surprisingly high ranking of 1 for Geographical scale of impact and Concern to Developing countries and CEIT, and ranked 2nd as Intervention priority. Again, presuming increased development in other regions, sewage related issues might also become greater elsewhere.

Other ECMIs that drew attention:

- Arsenic, ranked 10th on Aggregate concern, ranked 2nd on Climate change interactions.
- Phthalates, ranked 9 on Aggregate concern, ranked 4th on Impact on ecosystems and 6th on Climate change interactions.

The lowest ranked ECMIs were Alkylphenols and Marine debris in joint 21st position, BPA (20), Illicit drugs (19), and Ammunition and conflict (18).

Regarding Intervention priority, Mine waste (ranked 8th on Aggregate concern) was the highest ranked. In joint 2nd rank for intervention priority was Inorganic fertilizer (ranked 5th on Aggregate concern), Sewage (ranked 6th on Aggregate concern), and Open burning (ranked 3rd on Aggregate concern)

Oceania

Because responses were only received from four respondents from the Oceania region, it is likely that a future survey may show different rankings. It must be noted though that Oceania probably also have much fewer potential respondents than the other, larger regions. However, there are some indicative rankings. Because of the low number of respondents, many ECMIs shared high rankings and only the highest and lowest aggregate ranked ECMIs will be highlighted.

Oceania had ranking patterns that differed from the four larger regions (Table 6.8). Open burning was ranked 1st on Aggregate concern due to concern rankings for Impact on ecosystems (1) and geographic scale of impact (1). Other concern criteria contributing were Transboundary issues (2), Impact on human health (2), Climate change interactions (2), and Economis and social interactions.

TABLE 6.8. Ranked concern criteria for Oceania for the 22 ECMIs as rated by four respondents.

ECMI	Concern to DC&CEIT	Trans-boundary issues	Impact on ecosystems	Impact on human health	Climate change interactions	Economic/social interactions	Intervention priority	Geographical scale of impact	**Aggregate concern rank**
Open burning	3	2	1	2	2	2	4	1	**1**
PAHs	1	10	1	2	8	1	1	8	**2**
Heavy metals	1	10	1	1	1	7	9	4	**3**
Marine debris	5	2	1	7	14	3	4	1	**4**
Sewage sludge	3	10	7	2	3	3	13	1	**5**
Ammunition/conflict	6	4	7	10	8	10	1	6	**6**
Inorganic fertilizer	9	4	1	7	14	7	9	8	**7**
E-waste	6	4	1	7	19	15	4	8	**7**
Arsenic	12	7	21	10	3	3	13	8	**9**
Cadmium in fertilizer	12	7	15	10	8	6	9	8	**10**
Mine waste	6	10	13	18	14	10	4	4	**10**
Organotins	16	7	7	2	19	15	8	15	**12**
Endocrine disruption	9	10	15	10	7	7	12	15	**12**
PPCPs	19	17	15	14	3	15	1	15	**14**
Mixture effects	9	10	15	2	21	10	19	8	**15**
Lead in paints	12	17	15	16	3	18	13	8	**16**
Illicit drugs	12	21	7	14	8	20	19	6	**17**
Bisphenol A	19	1	21	21	8	10	13	18	**18**
Alkylphenols	16	17	7	18	14	10	13	18	**18**
Phthalates	16	17	7	20	14	18	13	18	**20**
Food additives	21	10	15	16	8	20	22	21	**21**
Nanoparticle/material	22	21	13	21	22	20	21	21	**22**

PAHs was 2^{nd} on Aggregate concern ranking, due Intervention priority (1), Economic and social interactions (1), Impact on ecosystems (1) and Concern to Developing Countries and CEIT. Respondents clearly were very concerned about these two interlinked ECMIs and this needs concerted attention and intervention.

Ranked in 3^{rd} position on Aggregate concern was Heavy metals due to high concern rankings for Climate change interactions (1), Impact on human health (1), Impact on ecosystems (1), and Concern to Developing countries and CEIT (1).

Marine debris in Oceania reached its highest Aggregate concern for any region (4) due to Impact on ecosystems (1), Geographic scale of impact (1), and Transboundary issues (2). Clearly, the respondents felt the region sensitive to marine debris impacts.

Likewise, Sewage reached its highest Aggregate concern rank (5) in Oceania. High concern rankings were from Geographic scale of Impact (1) and Impact on human health (2). It seems that small islands have serious problems with this ECMI.

Ammunition and conflict also reached its highest Aggregate concern rank in Oceania (6). It was given an Intervention priority rank of 1 and ranked 4^{th} for Transboundary issues, indicating that legacy issues from war and conflict may pose an under-appreciated problem for large parts of the region.

Other ECMIs to take note of are:

- Bisphenol A (BPA) got top ranking for Transboundary issues, but the reasons are not clear. It may have to do with products entering the region containing BPA, or it may be associated with Marine debris.
- Arsenic ranked 3rd on both Climate change interactions and Economic and social interactions. This ECMI needs to be watched in the future.
- Organotins, surprisingly, got a high rank of 2 for Impact on human health. Organotins, especially TBT, is well-known for its effects on marine gastropods. Concern about human health due to consumption of TBT polluted seafood might be reason for this high rank.
- Given the intensive use of agricultural lands on islands, the top rank (1) for Impact on ecosystems for Inorganic fertilizer seems valid. Since inorganic fertilizer could pollute international waters, Transboundary issues was ranked in 4th position.
- Mine waste was ranked 4th on Intervention priority and on Geographical scale of impact.

The lowest ranked ECMIs on Aggregate concern were Nanoparticles and materials (22), Food additives (21), Phthalates (20), and PBA and Alkykphenols jointly ranked in 18^{th} position.

Intervention priorities were PAHs, linked to Open burning, Ammunition and conflict, and PPCPs. PPCPs may be linked with BPA (ranked 1^{st} on Transboundary issues), Illicit drugs (ranked 6^{th} on Geographical scale of impact), and Mixture effects (ranked 2^{nd} for Impact on human health).

The low response indicates that the ranking effort should be repeated for the Pacific region and that the results presented here should be interpreted with caution.

Summary of regional rankings

A summary of highest and lowest ranked ECMIs is presented in Table 6.9. For all regions except Oceania, Heavy metals was ranked highest on Aggregate. PAHs was ranked 2nd-4th in all regions. Mixture effects, although not featuring a top rank in any region, ranked 3rd in the four larger regions, and 4th when Oceania was included. Open burning was ranked in 4th overall position although only having top rank in Oceania. With Oceania included in the rankings, PAHs and Open burning were ranked 4 and 3, respectively. The top priorities (1) in all regions are present in the ranked top four for the regions combined, with or without Oceania.

Endocrine disruption ranked in 5th position (or 6th with Oceania) on Aggregate concern, with only 4th ranking on Aggregate concern for Asia and Central and South America. Sewage ranked in 6th position (or 5th with Oceania) on Aggregate concern due to 5-6 rankings only in Central and South America, Eastern Europe, and Oceania. Inorganic fertilizer,

TABLE 6.9. Regional and all-regional ECMIs summarized on Aggregate concerns.

ECMI	Central & South America	Africa	Asia	Eastern Europe	Oceania	**All regions - Oceania**	**All regions + Oceania**
Heavy metals	1	1	1	1	3	**1**	**1**
PAHs	3	2	2	4	2	**2**	**2**
Mixture effects	2	7	6	2	15	**3**	**4**
Open burning	5	5	3	3	1	**4**	**3**
Endocrine disruption	4	12	4	7	12	**5**	**6**
Sewage	6	10	12	6	5	**6**	**5**
Inorganic fertilizer	8	9	13	5	7	**7**	**7**
Arsenic	10	11	5	10	9	**8**	**9**
E-waste	13	3	7	14	7	**9**	**8**
PPCPs	7	8	15	11	14	**10**	**11**
Mine waste	11	14	11	8	10	**11**	**10**
Lead in paints	17	4	8	15	16	**12**	**13**
Illicit drugs	9	6	18	19	17	**13**	**14**
Cadmium in fertilizer	12	15	10	16	10	**14**	**12**
Food additives	15	13	14	13	21	**15**	**16**
Phthalates	16	17	16	9	20	**16**	**17**
Bisphenol A	19	20	9	20	18	**17**	**19**
Organotins	18	21	17	12	12	**18**	**18**
Marine debris	14	19	19	21	4	**19**	**15**
Alkylphenols	20	18	20	21	18	**20**	**21**
Ammunition/conflict	22	16	22	18	6	**21**	**20**
Nanoparticle/material	21	22	21	17	22	**22**	**22**

ranked 7th overall, had higher concerns in Eastern Europe (5) and Oceania (7), while Arsenic ranked 8 on Aggregate concern was due to Asia (5). E-waste ranked in 9th position (or 8th with Oceania), due to Africa (3).

The ECMIs that ranked consistently in the bottom seven in all regions were Phthalates, BPA, Organotins, Marine debris (ranked 4th in Oceania), Alkylphenols, Ammunition and conflict (ranked 6th in Oceania), and Nanomaterials and particles.

A closer look at scientific confidence

The respondents were drawn from across the globe and were asked to respond from their perspectives and not their research strengths, which seems to have been the case. There are several interpretations regarding scientific certainty that can be gleaned from this ranking (consider Table 6.10 together with Table 6.9):

- Heavy metals clearly had very good scientific foundation on which the respondents based their assessments.
- Arsenic was deemed to have a very high (2) scientific confidence, in between Heavy metals (1) and PAHs (3),
- Despite significant research literature and attention on compounds such as BPA, Alkylphenols, and Phthalates, scientific knowledge on these compounds did pose a significant problem in Developing Countries and CEIT (Table 6.10). This is also mirrored in the rankings of Endocrine disruption and Mixture effects. However, while BPA, Alkylphenols, and Phthalates ranked low in almost all regions and globally, Endocrine disruption and Mixture effects ranked very high everywhere (Table 6.9) (and Illicit drugs to a lesser extent). The respondents therefore seemed to consider individual compounds to be more of a problem in mixtures than as individual compounds, and that action is required to reduce exposures to the 'chemical soup' rather than addressing individual compounds. Heavy metals and PAHs, however, were ranked 1 and 2 on Aggregate concern above Mixture effects (Table 6.9), indicating these two ECMIs to be the most important.
- In contrast, Nanoparticles and materials was ranked low in both scientific confidence (Table 6.10) and in regional and aggregate priority (Table 6.9). Only in Eastern Europe did this ECMI rank higher than the bottom two positions, at Aggregate rank 9. The message here may be that as countries progress on their development trajectories and have tackled their ECMIs of immediate high-concern, other ECMIs will then attain higher priority. Phrased differently, while an ECMI such as plasticizers may have as great a concern and impact in Developing countries and CEIT as in Developed Countries, there are even greater concerns about other ECMIs such as PAHs and Heavy metals in Developing countries and CEIT. How to balance these concerns remains a challenge for the international community.

TABLE 6.10. Summarized knowledge and research profile.

ECMI	High confidence	Intermediate confidence	Poor confidence	No knowledge
Heavy metals	1	19	22	21
Arsenic	2	12	19	15
PAHs	3	5	16	21
Lead in paints	4	2	20	15
Sewage	4	5	13	20
Inorganic fertilizer	6	1	20	18
Mine waste	7	9	16	6
Open burning	8	12	8	12
Cadmium in fertilizer	9	5	15	13
Endocrine disruption	10	12	3	15
Organotins	12	12	16	6
Illicit drugs	12	18	9	6
Mixture effects	12	21	1	18
Bisphenol A	15	12	9	6
PPCPs	15	2	13	4
Nanoparticle/materials	17	22	6	2
Phthalates	18	9	9	3
Alkylphenols	19	2	12	4
Food additives	19	5	6	11
E-waste	21	9	9	13
Ammunition/conflict	21	20	4	1
Marine debris	22	12	2	6

- Lead in paints, probably a typical situation restricted to Developing Countries, had good scientific certainty, but only attained a high Aggregate concern (4) in Africa. Although there is very little known on the actual effects of lead in paints, research from other lead exposures were used to derive the scientific certainty, and to rank this issue as a high priority in Africa where lead in paints was deemed to be a serious problem.

- Both Mixture effects and Endocrine disruption ranked very high in Poor confidence ranking (1 and 3, respectively), but they did not rank lower than 12 in any region in terms of priority (Table 6.9). Likely, the respondents took into account information from elsewhere and applied prudent scientific extrapolation as to how real-world conditions in Developing Countries and CEIT translate into exposure and effects.

- E-waste and Open burning consistently did not score very high in any category of scientific confidence (Table 6.10), indicating perhaps three considerations more prevalent in Developing Countries and CEIT:
  - a possible ambivalence to existing knowledge;
  - a strong research need; and
  - despite much needed research and information, the necessity to intervene in E-waste and open burning where it occurs is already considered an urgent priority.

- Heavy metals, as the highest-ranked ECMI on Aggregate concern (Table 6.9), was associated with high scientific certainty and available management options. This combination identifies Heavy metals as probably the most important ECMI that can be addressed by international concerted action. Given that a number of other ECMIs are associated with Heavy metals (Lead in paints, Organotins, Nanoparticles and nanomaterials, Cadmium in fertilizer, E-waste, Mixture effects, Ammunition and conflict, Arsenic (as a metalloid), Mine waste, and Sewage as the more obvious (but see also Table 6.2), concerted international intervention regarding Heavy metals and its causes may address multiple related ECMIs synergistically.

- The fertilizer associated ECMIs (Inorganic fertilizer and Cadmium in fertilizer) had reasonable scientific confidence (Table 6.10), and attained high aggregate priority ranking is in the Pacific, Central and South America, and Eastern Europe (Table 6.9). Clearly, some ECMIs have a more regional than local priority, but their high regional rankings strongly suggest that its mitigation would have Global Environmental Benefits.

- Mine wastes and drainage, Arsenic, and Inorganic fertilizers are all associated with geology. These ECMIs seem to represent serious but more localized issues, although they all share a Heavy metal association. However, since the products of these ECMIs (except for arsenic) have interactions with international trade component, it qualifies as a global issue with localized impacts. This could be seen as almost the inverse of the Stockholm Convention approach where geographically restricted uses or sources of POPs have global consequences.

- The organic compounds were rated lower both in the concern criteria and in scientific knowledge. This may partially reflect the success of the Stockholm Convention (but also many regulated by the Rotterdam Convention and the Basel Convention) that specifically addresses the most serious organic compounds with a global impact – compounds not considered here. On the other hand, the less persistent organics such as PPCPs, Phthalates, BPA, Alkylphenols, and Illicit drugs may eventually also become important depending on new investigations, but its current assessment is hampered by a serious lack of scientific information. However, many of the organic compounds are part of the 'chemical soup' that presumably resulted in high ranks for Mixture effects and Endocrine disruption.

- Lack of scientific knowledge will be a serious constraint for addressing many of the remaining ECMIs, and a watch on these ECMIs may need to be kept to follow new developments, as well as advising on timely and prudent intervention when the need is indicated, especially in Developing Countries and CEIT.

- Capacity for research and monitoring is of course always an issue in Developing countries and CEIT. However, country-level and regional level rankings as done here may show the need to strengthen research and monitoring capacity for specific high-ranked ECMIs, while keeping track of other ECMIs that may become more prominent in the future. Existing MEAs have this as mandate as well, but a broader needs assessment may indicate more effective application of resources.

Assessment of the survey

Potential bias from the respondents

Several observations from the rankings indicate little bias from the respondents based on knowledge, news profiles of ECMIs, experience, or funding opportunities. For instance, only a few of the respondents would have had direct or principal professional exposure to Arsenic, yet it had consistently higher rankings than E-waste, PPCPs, and Lead in paints, all ECMIs with relatively high international profiles. Nanoparticles and materials as ECMI has a high public and scientific profile and represents potential research funding opportunities in Developing Countries and CEIT. However, this ECMI consistently ranked very low in all regions. Knowledge bias was therefore deemed not have played a significant role.

The results therefore show the advantage of using the broad membership base of an international scientific organization (SETAC) that holds regional and global conferences. By interacting in a global commons (regular newsletters, participating in working groups, and by attending conferences), members (including those from Developing countries and CEIT) are aware of the latest scientific developments and pollution issues from across the globe.

Comments from respondents

The comments of the respondents provided in Chapter 5 proved to be insightful. Bearing in mind that they were all from or representing Developing Countries and CEIT, there were strong and common themes such as a lack of information, data, research capacity, effective regulation, and effective enforcement of regulations. A sense of frustration about lack of knowledge was also discernable.

From the comments it also seemed that the rapidly expanding nature of some ECMIs is probably too quick for many Developing Countries and CEIT to anticipate, track, respond to timely, or even to act preventatively. Rapidly evolving ECMIs represent a difficult enough challenge even for the developed economies and economic groupings. Added to this is that production, use, release, and exposure scenarios in Developing Countries and CEIT are often different from Developed Countries. Therefore, copying regulations from Developed Countries may be entirely misdirected (and perhaps even contra-productive), and may even not be needed if a particular ECMI is not relevant, dominant, or present. A lack of data or information is a serious constraint when dealing with ECMIs in Developing Countries and CEIT.

Additional questions

The respondents were asked several additional questions. These are listed below with responses provided unedited except for corrections to spelling.

The respondents were asked to suggest more effective interventions that could address management needs of multiple ECMIs:

- The concern for environmental pollutants strongly rule commercial requirements, mainly from Europe or USA. But in the case of production-chains oriented to the internal market, the environmental rules and controls are very lazy.
- Knowledge of these (topics) is currently very limited.
- Government commitment and mass involvement of all stakeholders.
- Control of import, manufacture and distribution/use may be applicable to more than one issue as an effective way is to control the materials entering the country and developments. Furthermore, a best option is to remove the hazardous materials that we can treat it in our country to some place where it can be disposed.
- Regional cooperation, information sharing, training of enforcement agencies and provision of monitoring equipment.
- More effective to consider addressing intervention strategies by group of pollutants produced for a specific activity, for example.

The respondents were also asked to provide additional suggestions that would benefit ECMI assessment by the GEF. Some suggestions were:

- Create special links with ongoing SAICM projects.
- At the moment, only international regulation could enforce the change in environmental management because it could put the ECMI in the political agenda. Situation maybe in some future could be prioritized by a national social movement, but in a worst future environmental scenario.
- Establish a database for researchers to use so as to avoid duplication of efforts.
- Transfer of modern technologies for identification, disposal, and control of chemicals is as important as prescribing solutions.
- Strengthen our environment monitoring capability to help increase our capacity.

Success of survey

The prioritizing was successful in deriving global and regional priorities but there is still room for improvement:

- More respondents are needed from Oceania to confirm or change that region's priorities.
- The survey was felt by some respondents to be too long.
- Scientists seem to be less confident about answering questions about management options and MEAs.
- The regions covered by the surveys were quite diverse. More region-specific surveys would enable a greater understanding of the sub-regional's issues and priorities.
- Future surveys could be translated into other languages.
- One responded said "For a more exact ECMI assessment, a more specific questionnaire has to be developed."

CHAPTER 7

Conclusions and Recommendations

The current set of 22 ECMIs was identified without attempting watertight separation between them. The overlaps and interactions between the ECMIs are presented in Table 6.2. This table should be consulted to identify where interventions on a specific ECMI would also address and potentially mitigate other ECMIs. Co-benefits with multiple ECMIs would therefore add to cost-effectiveness of interventions. Based on the analyses, the results of the survey, and comments from the respondents, the following specific and general results and conclusions are presented.

General

- The world is experiencing an increasing complexity of chemical management issues.
- The scope and extent of some or most ECMIs are increasing, resulting in more pressures on human health and the environment.
- Some of the ECMIs under consideration have been recognized as important issues in the past, but their impacts are now either increasing and/or its threats are now better understood.
- Many of the ECMIs represent a serious environmental and human health threat, especially in many of the Developing Countries and CEIT that lack effective regulation and/or enforcement.
- This report analyzed crosscutting issues and interactions between the ECMIs. The interactions and crosscutting issues involved create complexities that make interventions to address an ECMI in isolation almost impossible.
- ECMIs, if not addressed timely and adequately, will increasingly become a drag on social wellbeing and stability, environmental sustainability, and economic progress.
- A lack of regulation and enforcement also allows deliberate disregard for the common good, and may result in the compromise of human health and environmental integrity.
- Some ECMIs, such as Cadmium in fertilizers, Lead in paints, Illicit drugs, Food additives deliberately used for adulteration, and Ammunition and conflict, despite adequate evidence and well-known health and environmental hazards, are characterized by at least some deliberate disregard of the common good. The continued and regular disclosures of food and feed adulteration in Developed Countries, as well as in Developing Countries and CEIT, probably represents only a small proportion of actual cases.
- Interventions on specific issues in countries and regions on a specific ECMI may have unintended consequences elsewhere. For example, closing down (or regulating) illegal or harmful E-waste processing in one country or region may result in such processing moving somewhere else. E-waste and possibly other such ECMIs, although a regional activity, should therefore be considered a global ECMI as the activities might shift elsewhere. The high Aggregate concern ranking of E-waste in Oceania might already be an indication of such shifts, but that needs further investigation.
- Geology-related ECMIs (mining and fertilizers) have mainly local impacts but the products of these activities are shipped globally. Spreading the advantages of the products globally therefore qualifies localized ECMI impacts as global although the production impacts are localized. Corrective interventions on a localized level will therefore have global environmental benefits.
- Copying the regulations from Developed Countries may be misdirected (perhaps even counter-productive), and may in some cases not be needed if a particular ECMI is not relevant or present.
- A great deal of knowledge on ECMIs is derived from Developed Country investigations, but lack accurate extrapolation power to Developing Countries and CEIT scenarios. However, even with this lack of local knowledge, it is obvious, based on knowledge from elsewhere, that intervention on certain ECMIs is required, and that management options are available.
- Many ECMIs are more common in (and sometimes almost exclusive to) Developing Countries and CEIT. Therefore, research and monitoring capacity that are specific to the needs of Developing Countries and CEIT is needed that are less reliant on Developed Country experiences and needs.

Developed Country research is often geared towards their own priorities and situations, possibly skewing the research and aid efforts towards ECMIs that are shared rather than characteristic of Developing Countries and CEIT.

- Interventions, mitigations, alternatives, and disposal options are often available, but may need local adaptation and/or proof of implementability.
- Some ECMIs are partially addressed by some form of local, regional, or global intervention or instrument, indicating effective mitigation experience and some capacity to intervene.
- Existing multilateral modes of intervention and assistance needs to be explored further

Specific

- An assessment of interactions between ECMIs (Table 6.2) showed that Mixture effects had the most interactions with other ECMIs, followed by Endocrine disruption, Heavy metals, Marine debris, Sewage, and E-waste.
- In Developing Countries and CEIT, Heavy metals was the top priority on Aggregate concern, followed by PAHs, Mixture effects, Open burning, Endocrine disruption, Sewage, and Inorganic fertilizer.
- The ECMI ranked lowest on Aggregate concern were Phthalates, BPA, Organotins, Marine debris, Alkylphenols, Ammunition and conflict, and Nanoparticles and nanomaterials.
- In Central and South America, Heavy Metals was ranked highest on Aggregate concern, followed by Mixture effects, PAHs, Endocrine disruption, Open burning, and Sewage. Highest-ranked intervention priorities were Heavy metals, Mixture effects, Sewage, PAHs, and PPCPs.
- In Africa, Heavy metals and PAHs were highest ranked highest on Aggregate concern, followed by E-waste, Lead in paints, Open burning, and Illicit drugs. In terms of intervention priority, E-waste was ranked highest, followed by Heavy metals, Open burning, Illicit drugs, and Lead in paints, and Inorganic fertilizer.
- In Asia, Heavy metals was ranked the highest on Aggregate concern, followed by PAHs, Mixture effects, Open burning, and Endocrine disruption. As intervention priorities, Heavy metals and Open burning were ranked 1st and 2nd, followed by E-waste and Inorganic fertilizer. Arsenic and Mixture effects were jointly ranked 5th. Joint ranking of ECMIs may indicate the need for sub-regional prioritization. Arsenic for instance, may achieve a much higher ranking in some sub-regions.
- In Eastern Europe, Heavy metals topped the Aggregate concern list, followed by mixture effects, Open burning, PAHs, Inorganic fertilizer, and Sewage. Intervention priorities were slightly different from the other regions. Mine waste was top-ranked, followed by Sewage, and Inorganic fertilizer (jointly 2nd), Heavy metals and illicit drugs (jointly 4th), and PPCPs and Open burning (jointly 6th). Presuming that Eastern Europe is further along the developmental track, intervention priorities such as Sewage and Mine waste might increase in Intervention priority in other regions once their top priorities have been dealt with.
- Only four responses were received for Oceania. The results should therefore be treated with caution and the survey may need to be repeated. Highest-ranked aggregate priorities were Open burning, PAHs, Heavy metals, Marine debris, Sewage, and Ammunition and conflict. Intervention priority was highest for PAHs, PPCPs and Ammunition and conflict (jointly 1st), followed by Open burning, E-waste, Marine debris, and Mine waste (also jointly). Open burning and PAHs seems an obvious joint target for intervention.
- Open burning and PAHs are associated ECMIs with high intervention priorities and possibilities for mitigation by management. Some MEAS already address PAHs, but only on a regional scale.

Scientific confidence

- High regionally-specific scientific confidence was attributed to some ECMIs such as Heavy metals and PAHs.
- For the effects-based ECMIs (Endocrine disruption and Mixture effects), lower regionally specific scientific confidence was attributed, but the respondents were clearly au fait with current research findings and implications from elsewhere, indicating that a strong foundation exists to consider effects and impacts from multiple simultaneous exposures as a very high concern.
- Lack of regionally-specific scientific knowledge hampered the assessment of some ECMIs, indicating that a re-arrangement of priorities may occur when more data becomes available.

- Overall, a strengthening of research and monitoring capacity and activity in Developing Countries and CEIT is required. This need includes a need for strengthening scientific capacity on the 'older' ECMIs, such as Heavy metals, PAHs, and those associated with investigating and monitoring the Process related ECMIs.

Considerations

- Regional Aggregate concern rankings of ECMIs were done according to eight different (but overlapping) concern criteria. It is to be expected that ECMIs in different regions may have similar rankings but for different reasons or concerns. Interpretation and further actions need to take account of the differences in the reasons or concerns.
- Many of the ranked ECMIs are interlinked. For example, a reduction in Open burning will also reduce PAHs, Heavy metals, Endocrine disruption, and Mixture effects. In turn, this will also reduce impacts on Human health, Ecosystems, Economic and social interactions, and Climate change interactions.
- The differences between Aggregate concern rankings and Intervention priorities indicate that some ECMIs should be addressed over a longer term. However, addressing the higher intervention priority ECMIs will also reduce the impacts of some of the higher-ranked Aggregate concern priorities due to interlinkages as represented in Table 6.2.
- Lower-ranked ECMIs may be a greater problem than represented here due to insufficient data and science.
- It should also be kept in mind that lower-ranked ECMIs could be as big a problem in Developing Countries and CEIT as in Developed Countries, but that higher-ranked ECMIs present an even larger challenge. Lower-ranked ECMIs are therefore not necessarily less of a problem, but are overshadowed by others.
- Respondents consistently ranked the effects-based ECMIs (Endocrine disruption and Mixture effects) very high on Aggregate concern. This represents a realization that humans, biota and ecosystems deal with a myriad of chemicals in different combinations (the 'chemical soup'), with multiple effects at sub-lethal levels.
- Many of the lower-ranked ECMIs are also subsumed within higher Aggregate concerns ECMIs such as Endocrine disruption and Mixture effects. Addressing the higher-ranked Aggregate concerns will most likely address some of the lower ranked ECMIs such as BPA, Phthalates, and Alkylphenols. Respondents signaled that piece-meal approach would have lesser benefits than an integrated approach.
- Some ECMIs were ranked higher on Aggregate concern, but different from their Intervention need. This dichotomy can be explained by considering that as countries are dealing with ECMIs of immediate high-concern as part of their development trajectories, other ECMIs will then attain higher priority. Phrased differently, while an ECMI such as plasticizers may have as great a concern and impact in Developing countries and CEIT as in Developed Countries, there are even greater concerns about other ECMIs such as PAHs and Heavy metals in Developing countries and CEIT. While management interventions are adapted to address the highest concern ECMIs, Developed Countries develop mitigation measures from which Developing countries can subsequently learn from and adopt. How to balance competing concerns remains a challenge for the international community.

Recommendations

The interactive and complex nature of the 22 ECMIs under consideration indicates that addressing these problems will be a challenge. The values represented by the economic, social, environmental, political, and health constituents need to be balanced in such a way that none are deprived, but all are strengthened. However, expectations may need to be compromised and re-aligned by the respective economic, social, environmental, political, and health custodians to prevent irreparable damage to the environmental matrix and its ability to support human life, dignity, and quality. A realization that problems should be anticipated and prevented, rather than managed after the fact, should eventually be the aim, but there are current pressing problems to be addressed first. There is, however, good reason to use the current challenges as opportunities to get into place the people and systems that will eventually enable prevention and improvement. Within the context of the ECMI challenges and priorities identified, the following are proposed:

- Consideration should be given to Heavy metals, Open burning, and PAHs as high priority targets for concerted international intervention. This issue probably represents the largest unaddressed chemical threat currently experienced in Developing Countries and CEIT.

- Since PAHs are already addressed by at least one regional MEA (the United Nations Economic Commission for Europe's Convention on Long-range Transboundary Air Pollution (LRTAP)), but also to reduce human exposure to PAHs from open fires used for cooking and heating in Developing Countries and CEIT.

- It seems prudent that urgent attention be given to mitigating Mixture effects and Endocrine disruption. Since Endocrine disruption can be seen as subsumed into Mixture effects, planning can be directed by combining these effects-based ECMIs as a topic for international concerted intervention. Consideration should also be given to the interaction Table 6.2, as many of the lower-ranked ECMIs would be involved in a higher-level effects-based ECMI that combines Mixture effects and Endocrine disruption.

- A more detailed assessment of each of the highest Aggregate concern ECMIs (Heavy metals, PAHs, Mixture effects, Open burning, Endocrine disruption, Sewage, Inorganic fertilizer, Arsenic, E-waste, and PPCPs) should be conducted on a global and regional basis to better investigate the conditions, intervention options, interactions with other ECMIs, global environmental and health benefits, and management options. This will serve as ECMI-specific frameworks for detailed intervention planning. Greater specific input should be sought from role players other than scientists, such as policy makers, Industry representatives, civil society, and NGOs. Institutions such as UNEP and SAICM are already working on guidance for ECMIs such as Endocrine disruption, some of the heavy metals, and E-waste. GEF/STAP has also produced guidance on Marine debris relevant to Developing Countries and CEIT.

- Serious and immediate attention should be given to implementing or strengthening regional and continental research and monitoring programs (such as GAPs and MONET), for ECMIs not currently covered by sometimes narrowly-mandated MEAs. Based on identified priorities, country-specific and regional research capacity must be enhanced to tackle identified priority ECMIs, but also taking note of the interactions indicated in Table 6.2.

- An ECMI observatory mechanism (similar to the European Risk Observatory) could be established that will assist in the timely translation of new scientific knowledge and new ECMIs (such as ECMIs on the horizon) into how they might affect Developing Countries and CEIT. Such an observation mechanism would be able to advise Developing Countries and CEIT, IGOs, and funding agencies on where research may be directed, and how this may be accomplished. Currently, many MEAs support fractionated investigations based on narrow mandates without the option of investigating emerging issues before a ponderous process of negotiations has been completed. This situation hampers the ability of Developing Countries and CEIT to eventually taking over more responsibility to address ECMIs and other environmental issues.

- This assessment only ranked the ECMIs, but made no attempt to quantify the issues on the ground. A better understanding of the amounts, activities, emission rates, sensitive communities, transboundary issues, areas to be rehabilitated, and other criteria need to be understood. Such a quantification exercise should incorporate all other major chemicals management issues such as POPs and mercury for which there are already adequate data.

- Consideration should also be given on how to interface the results from this assessment with other chemicals-focused assessments by institutions such as UNEP. UNEP, for instance, conducts the Chemicals outlook.

- An ECMI survey could be conducted every five years to track impact of interventions and to determine any changes in priorities, with a greater effort to collect regional specific information.

Specific guidance to The GEF

Because this assessment looked at Emerging Chemicals Management Issues, it was deliberately undertaken without direct reference to current GEF activities to encompass the entire scope of the chemical problems faced by Developing Countries and CEIT. This assessment deliberately excluded all issues already dealt with by existing MEAs, or MEAs under development to allow the identification of emerging (or perhaps long-neglected) needs in addition to those already addressed by MEAs and currently serviced by The GEF. STAP is in a good position to conduct such high-level guidance as it mandate from The GEF Council is focused on Developing Countries and CEIT considering transboundary issues and Global Environmental Benefits.

With this ECMI assessment, STAP has identified specific Emerging Chemical Management Issues that, when addressed, will enhance the environment and provide global benefits to societies, regions and ecosystems. From this assessment, it is obvious that Heavy metals, PAHs, and Open burning would be prime and immediate intervention candidates that could be added to the current concerns addressed by the Chemicals Portfolio of the GEF.

The GEF does not operate in isolation. In partnership with the GEF Agencies, within their respective mandates, through the GEF Chemicals Task Force, it is proposed that urgent attention be given to investigate how this assessment could inform the next replenishment. The GEF is an evolving organization that is responsive to the needs of its clients and donors, and associated MEAs. With a refined chemicals focus, the GEF will remain the prime funding organization for Developing Countries and CEIT. With this in mind, the following is proposed to GEF Council:

- This assessment is proposed to help inform GEF Council for the next replenishment of the GEF.
- To consider initiating the development (where appropriate in partnership with other Agencies) of specific intervention guidance on:
  - Heavy metals
  - PAHs and Open burning
  - Mixture effects (incorporating Endocrine disruption)
  - Inorganic fertilizers
  - Sewage
  - Arsenic
  - E-waste
- To consider developing guidance on how the chemicals management issues (current and new) can interface with the other Focal Areas of the GEF, as well as with agenda's such as urbanization and health that are currently not a focus within the GEF. The Marine Debris guidance is an example where Chemicals, International Waters, and Biodiversity interfaced while also considering health and urbanization.

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