GLOBAL CHEMICALS OUTLOOK II
FROM LEGACIES TO INNOVATIVE SOLUTIONS
IMPLEMENTING THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT
About the Global Chemicals Outlook II

The first edition of the *Global Chemicals Outlook*, published in February 2013, assembled scientific, technical and socio-economic information on the sound management of chemicals. It covered trends and indicators for chemical production, transport, use and disposal, and associated health and environmental impacts; economic implications of these trends, including costs of inaction and benefits of action; and instruments and approaches for sound management of chemicals.

Decision 27/12, adopted by the Governing Council of the United Nations Environment Programme in 2013, recognized the significance of the findings of the first *Global Chemicals Outlook*, which highlighted the significant increase in the manufacture and use of chemicals globally, their importance to national and global economies and the costs and negative effects on human health and the environment of unsound chemicals management, and made recommendations for future action. Decision 27/12 also requested the Executive Director to continue work on the *Global Chemicals Outlook*, particularly in areas where data were found to be lacking or inadequate, and to enhance transparency through regionally balanced stakeholder involvement, inter alia, with a view to developing in the future a tool for assessing progress towards the achievement of the sound management of chemicals and hazardous wastes, including the existing 2020 goal, taking into account and building upon other existing sources of information.

Resolution 2/7, adopted by the United Nations Environment Assembly in 2016, requested the Executive Director to submit an update of the first *Global Chemicals Outlook*, addressing, inter alia, the work carried out particularly in relation to lacking or inadequate data to assess progress towards the 2020 goal, the development of non-chemical alternatives, and the linkages between chemicals and waste, in coordination with the *Global Waste Management Outlook*, and providing scientific input and options for implementation of actions to reach relevant Sustainable Development Goals and targets up to and beyond 2020. Resolution 2/7 also requested the Executive Director to ensure that the updated *Global Chemicals Outlook* addresses the issues which have been identified as emerging policy issues by the International Conference on Chemicals Management (the governing body of the Strategic Approach to International Chemicals Management) as well as other issues where emerging evidence indicates a risk to human health and the environment.

The second edition of the *Global Chemicals Outlook* has been prepared with substantive contributions from more than 400 experts and under the guidance of a Steering Committee, which provided oversight, strategic directions and guidance on all aspects of the report’s development, as well as technical inputs, where applicable. The Steering Committee was composed of representatives from Governments, non-governmental organizations (including civil society, industry/the private sector, and academia) and inter-governmental organizations, with participation from all regions and a wide range of stakeholders.

The *Global Chemicals Outlook II* is complemented by the *Global Chemicals Outlook II Summary for Policymakers* and the *Global Chemicals Outlook II Synthesis Report*. The *Synthesis Report* summarizes key findings and insights of the full report and follows the same five-part structure. It was launched at the fourth session of the United Nations Environment Assembly in March 2019. The shorter *Summary for Policymakers* was tabled as a working document of the fourth session of the United Nations Environment Assembly and is available in all six UN languages.
The Global Chemicals Outlook II has been developed through substantive input from a wide range of experts, and through collaboration with numerous partner organizations. The United Nations Environment Programme wishes to thank all individuals and organizations that have generously contributed their expertise, time, and energy.

The Steering Committee provided oversight, strategic direction, guidance and technical inputs throughout the process. The members of the Committee were: Keith Alverson, Ingela Andersson, Heidar Ali Balouji, Ricardo Barra, Andrea Brown, Leticia Carvalho, Emma Chynoweth, Bob Diderich, Joe DiGangi, Szymon Domagalski, Jutta Emig, Richard Fuller, Veronique Garny, Fernando Gomez, Florencia Grimalt, Bjorn Hansen, Juergen Helbig, Sverre Thomas Jahre, David Kapindula, Brenda Koekkoek, Brian Kohler, Kouame Georges Kouadio, Klaus Kümmerer, Mungath Kutty, Vladimir Lenev, Suzanne Leppinen, Jianguo Liu, Christoph Neumann, Jorge Ocaña, Hanna-Andrea Rother, Tatiana Santos, Claudia ten Have, Baskut Tuncak, Carolyn Vickers, Melissa Mengjiao Wang, Katherine Weber, Felix Wertli, Susan Wilburn, and Kei Ohno Woodall. Back-up support to members of the Committee was provided by, among others, Angelina Buchar, Tracey Easthope, Manoj Kumar Gangeya, Vassilios Karaveziris, Sunday Leonard, Eugeniy Lobanov, Andrew McCartor, Geraint Roberts, Dolores Romano, Leigh Stringer, Michel Tschirren, Victoria Tunstall, and Carla Valle-Klann.

Lead authors responsible for the drafting of foundational papers and specific chapters were: Francisco Alpizar, Thomas Backhaus, Nils Decker, Ingo Eilks, Natalia Escobar-Pemberthy, Peter Fantke, Ken Geiser, Maria Ivanova, Olivier Jolliet, Ho-seok Kim, Kelvin Khisa, Haripriya Gundimeda, Daniel Slunge, Stephen Stec, Joel Tickner, David Tyrer, Niko Urho, Rob Visser, Mario Yarto, and Vania Gomes Zuin. Ken Geiser served as coordinating author for Part I. Rob Visser served as coordinating author for Parts II and III. Lead authors for capturing regional perspectives were Babajide Alo, Vera Barrantes,
Further substantive contributions were provided by: Katinka De Balogh, Marie-Ange Baucher, Richard Blume, Rafael Cayuela, Maria Delfina Cuglievan, Heidelore Fiedler, John Haines, Lei Huang, Nicole Illner, Molly Jacobs LeFevre, Edwin Janssen, Elisabeth Krausmann, Nyree Bekarian Mack, Rachel Massey, Frank Moser, Amos Necci, Ieva Rucevská, David Sutherland, Urvi Talaty, Dirk Uhlemann, Elze van Hamelen, Willem van Lanschot, Melissa Mengjiao Wang, Zhanyun Wang, Maureen Wood, Oliver Wootton, and Evetta Zenina.

A Consultative Meeting for the Preparation of the Global Chemicals Outlook II took place in April 2016 in Geneva, Switzerland. It was attended by 70 experts. Subsequently a wide range of stakeholders provided input at five workshops. These consisted of a series of regional expert workshops in March-April 2018 in Nairobi, Kenya (Africa); Frankfurt, Germany (Europe, including Central and Eastern Europe); Panama City, Panama (Latin America and the Caribbean and North America); and Bangkok, Thailand (Asia-Pacific and West Asia), attended by a total of 115 participants; and a global workshop (June 2018, Bonn, Germany) with some 100 participants. Paul Hohnen provided valuable support, including by moderating sessions at several workshops.

Independent experts, identified based on nominations received from the Scientific and Technical Advisory Panel of the Global Environment Facility, the secretariat supporting the preparation of UNEP Environment's sixth Global Environment Outlook, and the International Solid Waste Association, were invited to review the draft GCO-II. In addition, external experts were invited to review selected sections based on their expertise. The following individuals provided valuable feedback: Marlene Agerstrand, Tom Bond, Weihsueh Chiu, Victoria de Higa, Paul Dumble, Henning Frieger, Martin Führ, Sarah Green, Jamidu Katima, Sayed Khattari, Joy Aeree Kim, Olwenn Martin, Ackmez Mudhoo, Carlos Ocampo Lopez, Stephen Macey, Prasad Modak, Naglaa Mohamed Loutfy, Jennifer McKellar, Percy Onianwa, Kamlesh Pathak, Andreas Previdnik, Alexander Romanov, Mark Rossi, Ted Smith, Gustavo Solorzano, Gerard Swaen, Mohamed Tawfic, Zijian Wang, and Meriel Watts.

Various organizations provided contributions to the development of the Global Chemicals Outlook II. The International Sustainable Chemistry Collaborative Centre (ISC3) (overall lead: Friedrich Barth; supported by Alexis Bazzanella, Nils Decker, Agnes Dittmar, Silke Megelski and Brigitta Meier) provided support in co-organizing the four regional workshops and the global workshop, as well as substantive contributions on megatrends and industry sectors. The International Panel on Chemical Pollution (overall leads: Martin Scheringer, Justin Boucher and Zhanyun Wang; supported by Thuy Bui, Dämien Bolinius, Elseemiek de Boer, Miriam Diamond, Patrick FitzGerald, Adelene Lai, Grégoire Meylan, Amélie Ritscher, Thomas Roiss, Christina Rudén, and Iona Summerson) undertook background research and prepared a foundational paper addressing the emerging policy issues and other issues of concern. The United Nations Institute for Training and Research (overall lead: Jorge Ocana; supported by Oliver Wootton and Ester Hermosilla) assisted by co-organizing meetings and workshops, as well as by facilitating delivery of substantive contributions.

The following entities provided comments and in-kind contributions throughout the process: the Inter-Organization Programme for the Sound Management of Chemicals participating organizations (Food and Agriculture Organization of the United Nations, International Labour Organization, United Nations Development Programme, United Nations Environment Programme, United Nations Industrial Development Organization, United Nations Institute for Training and Research, World Health Organization, World Bank, Organisation for Economic Co-operation and Development), the Secretariat of the Basel, Rotterdam and Stockholm Conventions, the Secretariat for the Minamata Convention, the Secretariat for the Vienna Convention and its Montreal Protocol.

The Global Chemicals Outlook II was prepared by the United Nations Environment Programme, Economy Division, Chemicals and Health Branch, and coordinated and edited by Achim Halpaap with Jost Dittkrist. Further valuable guidance, input and contributions have been provided by Jacqueline Alvarez, Abdouraman Bary, Llorenç Mila Canals, Kenneth Davis, Jacob Duer, Tessa Goverse, Mijke Hertoghs, Adam Hodge, Tim Kasten, Stephanie Laruelle, Isabelle Louis, Kaj Madsen, Imae Mojado, Kakuko Nagatani-Yoshida, Desiree Raquel Narvaez, Ligia Noronha, Jordi Pon, Pierre Quiblier, Liazzat Rabbiosi, Victor Hugo Estellano Schulze, Nalini Sharma, Ying Su, Eisaku Toda, Elisa Tonda, Eloise Touni, and numerous other colleagues. Administrative and other support has been provided by Erika Mattsson, Panos Kalogirou, Scholastica Theuri, Pascale Unger and Leila Younossi. Editing support has been provided by John Smith, graphic design and layout by Lowil Espada, with the support of Fabrice Clavien and Elsemieke de Boer, and referencing and data management support by Tapiwa Nxele.

Generous financial and in-kind contributions to develop the Global Chemicals Outlook II have been provided by the European Union and the Governments of Denmark, Germany, Norway, Sweden, and Switzerland.
Chemicals are part of our everyday lives. From pharmaceuticals to plant protection, innovations in chemistry can improve our health, food security and much more. However, if poorly used and managed, hazardous chemicals and waste threaten human health and the environment.

As the second Global Chemicals Outlook lays out, global trends such as population dynamics, urbanization and economic growth are rapidly increasing chemical use, particularly in emerging economies. In 2017, the industry was worth more than US dollars 5 trillion. By 2030, this will double. Whether this growth becomes a net positive or a net negative for humanity depends on how we manage the chemicals challenge. What is clear is that we must do much more.

Large quantities of hazardous chemicals and pollutants continue to leak into the environment, contaminating food chains and accumulating in our bodies, where they do serious damage. Estimates by the European Environment Agency suggest that 62 per cent of the volume of chemicals consumed in Europe in 2016 were hazardous to health. The World Health Organization estimates the burden of disease from selected chemicals at 1.6 million lives in 2016. The lives of many more are negatively impacted.

We have made some progress in managing chemicals through national and stakeholder action, international treaties and voluntary instruments. At the World Summit on Sustainable Development in 2002, countries committed to minimizing the adverse effects of chemicals by 2020. At our current pace, we will not achieve this goal. Considering the expansion of the market, and the associated increase in contamination, we cannot continue to gamble with our health.

Solutions do exist, as the report shows. Sustainable supply chain management, innovations in green and sustainable chemistry, and adopting common approaches to chemicals management can reduce the risks to human health, ecosystems and economies. But a solution is only as good as the will to implement it. Now, more than ever, key influencers such as investors, producers, retailers, citizens, academics and ministers must act. We have the chance to do what needs to be done. We are implementing the 2030 Agenda and developing a future framework for framework for the sound management of chemicals and waste beyond 2020.

We cannot live without chemicals. Nor can we live with the consequences of their bad management. My hope is that this Outlook inspires us all to increase our efforts to safely capture the benefits of chemistry for all humanity.

Joyce Msuya
Acting Executive Director
UN Environment
Key findings

The global goal to minimize adverse impacts of chemicals and waste will not be achieved by 2020. Solutions exist, but more ambitious worldwide action by all stakeholders is urgently required.

1. The size of the global chemical industry exceeded United States dollars 5 trillion in 2017. It is projected to double by 2030. Consumption and production are rapidly increasing in emerging economies. Global supply chains, and the trade of chemicals and products, are becoming increasingly complex.

2. Driven by global megatrends, growth in chemical-intensive industry sectors (e.g. construction, agriculture, electronics) creates risks, but also opportunities to advance sustainable consumption, production and product innovation.

3. Hazardous chemicals and other pollutants (e.g. plastic waste and pharmaceutical pollutants) continue to be released in large quantities. They are ubiquitous in humans and the environment and are accumulating in material stocks and products, highlighting the need to avoid future legacies through sustainable materials management and circular business models.

4. The benefits of action to minimize adverse impacts have been estimated in the high tens of billions of United States dollars annually. The World Health Organization estimated the burden of disease from selected chemicals at 1.6 million lives in 2016 (this is likely to be an underestimate). Chemical pollution also threatens a range of ecosystem services.

5. International treaties and voluntary instruments have reduced the risks of some chemicals and wastes, but progress has been uneven and implementation gaps remain. As of 2018, more than 120 countries had not implemented the Globally Harmonized System of Classification and Labelling of Chemicals.
6. Addressing legislation and capacity gaps in developing countries and emerging economies remains a priority. Also, resources have not matched needs. There are opportunities for new and innovative financing (e.g. through cost recovery and engagement of the financial sector).

7. Significant resources can be saved by sharing knowledge on chemical management instruments more widely, and by enhancing mutual acceptance of approaches in areas ranging from chemical hazard assessment to alternatives assessment.

8. Frontrunner companies – from chemical producers to retailers – are introducing sustainable supply chain management, full material disclosure, risk reduction beyond compliance, and human rights-based policies. However, widespread implementation of these initiatives has not yet been achieved.

9. Consumer demand, as well as green and sustainable chemistry education and innovation (e.g. through start-ups), are among the important drivers of change. They can be scaled up through enabling policies, reaping the potential benefits of chemistry innovations for sustainable development.

10. Global knowledge gaps can be filled. This can be achieved, for example, by taking steps to harmonize research protocols, considering health or environmental impact information and harm caused to set and address priorities (e.g. emerging issues), and strengthening the science-policy interface through enhanced collaboration of scientists and decision-makers.
## List of Abbreviations and Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACC</td>
<td>American Chemistry Council</td>
</tr>
<tr>
<td>ACS</td>
<td>American Chemical Society</td>
</tr>
<tr>
<td>AMAP</td>
<td>Arctic Monitoring and Assessment Programme</td>
</tr>
<tr>
<td>AMR</td>
<td>Antimicrobial resistance</td>
</tr>
<tr>
<td>AOP</td>
<td>Adverse Outcome Pathway</td>
</tr>
<tr>
<td>ASBC</td>
<td>American Sustainable Business Council</td>
</tr>
<tr>
<td>ASGM</td>
<td>Artisanal and small-scale gold mining</td>
</tr>
<tr>
<td>BCG</td>
<td>Boston Consulting Group</td>
</tr>
<tr>
<td>BHRRC</td>
<td>Business and Human Rights Resource Centre</td>
</tr>
<tr>
<td>BPA</td>
<td>Bisphenol A</td>
</tr>
<tr>
<td>BPS</td>
<td>Bisphenol S</td>
</tr>
<tr>
<td>BRS</td>
<td>Basel, Rotterdam and Stockholm</td>
</tr>
<tr>
<td>CAGR</td>
<td>Compound annual growth rate</td>
</tr>
<tr>
<td>CAPP</td>
<td>Chemical Accident Prevention and Preparedness</td>
</tr>
<tr>
<td>CEE</td>
<td>Central and Eastern Europe</td>
</tr>
<tr>
<td>Cefic</td>
<td>European Chemical Industry Council</td>
</tr>
<tr>
<td>CFC-11</td>
<td>Trichlorofluoromethane</td>
</tr>
<tr>
<td>CFCs</td>
<td>Chlorofluorocarbons</td>
</tr>
<tr>
<td>CIP</td>
<td>Chemicals in Products</td>
</tr>
<tr>
<td>CIRS</td>
<td>Chemical Inspection and Regulation Service</td>
</tr>
<tr>
<td>CLP</td>
<td>Classification, Labelling and Packaging</td>
</tr>
<tr>
<td>CMR</td>
<td>Carcinogenic, mutagenic and reprotoxic</td>
</tr>
<tr>
<td>CMS</td>
<td>Chemical management services</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>CO₂-eq</td>
<td>Carbon dioxide equivalent</td>
</tr>
<tr>
<td>COP</td>
<td>Conference of the Parties</td>
</tr>
<tr>
<td>DALYs</td>
<td>Disability-adjusted life years</td>
</tr>
<tr>
<td>DDT</td>
<td>Dichlorodiphenyltrichloroethane</td>
</tr>
<tr>
<td>DEHP</td>
<td>Bis(2-ethylhexyl) phthalate</td>
</tr>
<tr>
<td>EC</td>
<td>European Commission</td>
</tr>
<tr>
<td>ECHA</td>
<td>European Chemicals Agency</td>
</tr>
<tr>
<td>EDCs</td>
<td>Endocrine-disrupting chemicals</td>
</tr>
<tr>
<td>EEA</td>
<td>European Environment Agency</td>
</tr>
<tr>
<td>EFPIA</td>
<td>European Federation of Pharmaceutical Industries and Associations</td>
</tr>
<tr>
<td>EFSA</td>
<td>European Food Safety Authority</td>
</tr>
<tr>
<td>EHS</td>
<td>Environment, health and safety</td>
</tr>
<tr>
<td>EIPs</td>
<td>Eco-industrial parks</td>
</tr>
<tr>
<td>eMARS</td>
<td>EU Major Accident Reporting System</td>
</tr>
<tr>
<td>EPIs</td>
<td>Emerging policy issues</td>
</tr>
<tr>
<td>EPPP</td>
<td>Environmentally persistent pharmaceutical pollutants</td>
</tr>
<tr>
<td>ESDs</td>
<td>Emission Scenario Documents</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>EWG</td>
<td>Environmental Working Group</td>
</tr>
<tr>
<td>EY</td>
<td>Ernst &amp; Young</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
</tr>
<tr>
<td>GAHP</td>
<td>Global Alliance on Health and Pollution</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>GC3</td>
<td>Green Chemistry &amp; Commerce Council</td>
</tr>
<tr>
<td>GCO-I</td>
<td>First Global Chemicals Outlook</td>
</tr>
<tr>
<td>GCO-II</td>
<td>Second Global Chemicals Outlook</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross domestic product</td>
</tr>
<tr>
<td>GEF</td>
<td>Global Environment Facility</td>
</tr>
<tr>
<td>GHG</td>
<td>Greenhouse gas</td>
</tr>
<tr>
<td>GHS</td>
<td>Globally Harmonized System of Classification and Labelling of Chemicals</td>
</tr>
<tr>
<td>GPA</td>
<td>SAICM Global Plan of Action</td>
</tr>
<tr>
<td>GRI</td>
<td>Global Reporting Initiative</td>
</tr>
<tr>
<td>GRULAC</td>
<td>Group of Latin American and Caribbean Countries</td>
</tr>
<tr>
<td>GSCE</td>
<td>Green and sustainable chemistry education</td>
</tr>
<tr>
<td>HCFCs</td>
<td>Hydrochlorofluorocarbons</td>
</tr>
<tr>
<td>HDI</td>
<td>Human Development Index</td>
</tr>
<tr>
<td>HFCs</td>
<td>Hydrofluorocarbons</td>
</tr>
<tr>
<td>HHPs</td>
<td>Highly hazardous pesticides</td>
</tr>
<tr>
<td>HRC</td>
<td>Human Rights Council</td>
</tr>
<tr>
<td>HSLEEP</td>
<td>Hazardous substances within the life cycle of electrical and electronic products</td>
</tr>
<tr>
<td>IARC</td>
<td>International Agency for Research on Cancer</td>
</tr>
<tr>
<td>ICCA</td>
<td>International Council of Chemical Associations</td>
</tr>
<tr>
<td>ICCM</td>
<td>International Conference on Chemicals Management</td>
</tr>
<tr>
<td>IEA</td>
<td>International Energy Agency</td>
</tr>
<tr>
<td>IFIC</td>
<td>International Food Information Council</td>
</tr>
<tr>
<td>IFPMA</td>
<td>International Federation of Pharmaceutical Manufacturers and Associations</td>
</tr>
<tr>
<td>IGO</td>
<td>Intergovernmental organization</td>
</tr>
<tr>
<td>IHR</td>
<td>WHO International Health Regulations</td>
</tr>
<tr>
<td>ILO</td>
<td>International Labour Organization</td>
</tr>
<tr>
<td>ILZSG</td>
<td>International Lead and Zinc Study Group</td>
</tr>
<tr>
<td>IOMC</td>
<td>Inter-Organization Programme for the Sound Management of Chemicals</td>
</tr>
<tr>
<td>IP</td>
<td>Intellectual property</td>
</tr>
<tr>
<td>IPEN</td>
<td>International POPs Elimination Network</td>
</tr>
<tr>
<td>IPM</td>
<td>Integrated Pest Management</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>ISWA</td>
<td>International Solid Waste Association</td>
</tr>
<tr>
<td>IT</td>
<td>Information technology</td>
</tr>
<tr>
<td>IUPAC</td>
<td>International Union of Pure and Applied Chemistry</td>
</tr>
<tr>
<td>JPOI</td>
<td>Johannesburg Plan of Implementation</td>
</tr>
<tr>
<td>KEMI</td>
<td>Swedish Chemicals Agency</td>
</tr>
<tr>
<td>LAC</td>
<td>Latin America and the Caribbean</td>
</tr>
<tr>
<td>LCA</td>
<td>Life cycle assessment</td>
</tr>
<tr>
<td>LMICs</td>
<td>Low- and middle-income countries</td>
</tr>
<tr>
<td>MEA</td>
<td>Multilateral environmental agreement</td>
</tr>
<tr>
<td>Mt</td>
<td>Megatonne</td>
</tr>
<tr>
<td>NAFTA</td>
<td>North American Free Trade Agreement</td>
</tr>
<tr>
<td>Natech</td>
<td>Natural hazard triggered technological (accident)</td>
</tr>
<tr>
<td>ng</td>
<td>Nanogram</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-governmental organization</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>ODS</td>
<td>Ozone-depleting substance</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Cooperation and Development</td>
</tr>
<tr>
<td>OHS</td>
<td>Occupational Health and Safety</td>
</tr>
<tr>
<td>OOG</td>
<td>SAICM Overall Orientation and Guidance</td>
</tr>
<tr>
<td>OPS</td>
<td>SAICM Overarching Policy Strategy</td>
</tr>
<tr>
<td>PAHs</td>
<td>Polycyclic aromatic hydrocarbons</td>
</tr>
<tr>
<td>PAN</td>
<td>Pesticide Action Network</td>
</tr>
<tr>
<td>PBDEs</td>
<td>Polybrominated diphenyl ethers</td>
</tr>
<tr>
<td>PBT</td>
<td>Persistent, bioaccumulative and toxic</td>
</tr>
<tr>
<td>PCBs</td>
<td>Polychlorinated biphenyls</td>
</tr>
<tr>
<td>PCDDs</td>
<td>Polychlorinated dibenzo-p-dioxins</td>
</tr>
<tr>
<td>PCDFs</td>
<td>Polychlorinated dibenzofurans</td>
</tr>
<tr>
<td>PE</td>
<td>Polyethylene</td>
</tr>
<tr>
<td>PET</td>
<td>Polyethylene terephthalate</td>
</tr>
<tr>
<td>PFASs</td>
<td>Per- and polyfluoroalkyl substances</td>
</tr>
<tr>
<td>PFCs</td>
<td>Perfluorinated chemicals</td>
</tr>
<tr>
<td>PFDA</td>
<td>Nonadecafluorodecanoic acid</td>
</tr>
<tr>
<td>PFHxS</td>
<td>Perfluorohexanesulfonic acid</td>
</tr>
<tr>
<td>PFNA</td>
<td>Perfluorononanoic acid</td>
</tr>
<tr>
<td>PFOA</td>
<td>Perfluorooctanoic acid</td>
</tr>
<tr>
<td>PFOS</td>
<td>Perfluorooctanesulfonic acid</td>
</tr>
<tr>
<td>PFRs</td>
<td>Organophosphate-based flame retardants</td>
</tr>
<tr>
<td>pg</td>
<td>Picogram</td>
</tr>
<tr>
<td>PHAs</td>
<td>Polyhydroxyalkanoates</td>
</tr>
<tr>
<td>PLA</td>
<td>Polylactic acid</td>
</tr>
<tr>
<td>POPs</td>
<td>Persistent organic pollutants</td>
</tr>
<tr>
<td>PPE</td>
<td>Personal protective equipment</td>
</tr>
<tr>
<td>PRTRs</td>
<td>Pollutant Release and Transfer Registers</td>
</tr>
<tr>
<td>PTFE</td>
<td>Polytetrafluoroethylene</td>
</tr>
<tr>
<td>PV</td>
<td>Photovoltaic</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl chloride</td>
</tr>
<tr>
<td>PwC</td>
<td>PricewaterhouseCoopers</td>
</tr>
<tr>
<td>QSP</td>
<td>SAICM Quick Start Programme</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and development</td>
</tr>
<tr>
<td>REACH</td>
<td>Registration, Evaluation, Authorization and Restriction of Chemicals</td>
</tr>
<tr>
<td>Rio+20</td>
<td>United Nations Conference on Sustainable Development</td>
</tr>
<tr>
<td>RSC</td>
<td>Royal Society of Chemistry</td>
</tr>
<tr>
<td>SAICM</td>
<td>Strategic Approach to International Chemicals Management</td>
</tr>
<tr>
<td>SDGs</td>
<td>Sustainable Development Goals</td>
</tr>
<tr>
<td>SDS</td>
<td>Safety data sheet(s)</td>
</tr>
<tr>
<td>SEA</td>
<td>Socio-economic assessment</td>
</tr>
<tr>
<td>SEI</td>
<td>Stockholm Environment Institute</td>
</tr>
<tr>
<td>SMEs</td>
<td>Small and medium-sized enterprises</td>
</tr>
<tr>
<td>SVHC</td>
<td>Substances of very high concern</td>
</tr>
<tr>
<td>TCE</td>
<td>Trichloroethylene</td>
</tr>
<tr>
<td>TRI</td>
<td>United States Toxics Release Inventory</td>
</tr>
<tr>
<td>TSCA</td>
<td>United States Toxic Substances Control Act</td>
</tr>
<tr>
<td>UBA</td>
<td>German Environment Agency</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>UN</td>
<td>United Nations</td>
</tr>
<tr>
<td>UNCED</td>
<td>United Nations Conference on Environment and Development</td>
</tr>
<tr>
<td><strong>UN DESA</strong></td>
<td>United Nations Department of Economic and Social Affairs</td>
</tr>
<tr>
<td><strong>UNDP</strong></td>
<td>United Nations Development Programme</td>
</tr>
<tr>
<td><strong>UNEA</strong></td>
<td>United Nations Environment Assembly of the United Nations Environment Programme</td>
</tr>
<tr>
<td><strong>UNECE</strong></td>
<td>United Nations Economic Commission for Europe</td>
</tr>
<tr>
<td><strong>UNEP</strong></td>
<td>United Nations Environment Programme</td>
</tr>
<tr>
<td><strong>UNESCO</strong></td>
<td>United Nations Educational, Scientific and Cultural Organization</td>
</tr>
<tr>
<td><strong>UNIDO</strong></td>
<td>United Nations Industrial Development Organization</td>
</tr>
<tr>
<td><strong>UNISDR</strong></td>
<td>United Nations Office for Disaster Relief Reduction</td>
</tr>
<tr>
<td><strong>UNITAR</strong></td>
<td>United Nations Institute for Training and Research</td>
</tr>
<tr>
<td><strong>UNRISD</strong></td>
<td>United Nations Research Institute for Social Development</td>
</tr>
<tr>
<td><strong>US/USA</strong></td>
<td>United States</td>
</tr>
<tr>
<td><strong>US ATSDR</strong></td>
<td>United States Agency for Toxic Substances and Disease Registry</td>
</tr>
<tr>
<td><strong>US CDC</strong></td>
<td>United States Centers for Disease Control and Prevention</td>
</tr>
<tr>
<td><strong>US EPA</strong></td>
<td>United States Environmental Protection Agency</td>
</tr>
<tr>
<td><strong>US FDA</strong></td>
<td>United States Food and Drug Administration</td>
</tr>
<tr>
<td><strong>US GAO</strong></td>
<td>United States Government Accountability Office</td>
</tr>
<tr>
<td><strong>USGS</strong></td>
<td>United States Geological Survey</td>
</tr>
<tr>
<td><strong>US NASEM</strong></td>
<td>United States Academies of Science, Engineering and Medicine</td>
</tr>
<tr>
<td><strong>US NHANES</strong></td>
<td>United States National Health and Nutrition Examination Survey</td>
</tr>
<tr>
<td><strong>US NOAA</strong></td>
<td>United States National Oceanic and Atmospheric Administration</td>
</tr>
<tr>
<td><strong>US NRC</strong></td>
<td>United States National Research Council</td>
</tr>
<tr>
<td><strong>US NTP</strong></td>
<td>United States National Toxicology Program</td>
</tr>
<tr>
<td><strong>US OSHA</strong></td>
<td>United States Occupational Safety and Health Administration</td>
</tr>
<tr>
<td><strong>VCI</strong></td>
<td>German Chemical Industry Association</td>
</tr>
<tr>
<td><strong>VOCs</strong></td>
<td>Volatile organic compounds</td>
</tr>
<tr>
<td><strong>WBCSD</strong></td>
<td>World Business Council for Sustainable Development</td>
</tr>
<tr>
<td><strong>WECF</strong></td>
<td>Women in Europe for a Common Future/Women Engage for a Common Future</td>
</tr>
<tr>
<td><strong>WEEE</strong></td>
<td>Waste electrical and electronic equipment</td>
</tr>
<tr>
<td><strong>WEF</strong></td>
<td>World Economic Forum</td>
</tr>
<tr>
<td><strong>WEOG</strong></td>
<td>Western European and Others Group</td>
</tr>
<tr>
<td><strong>WIPO</strong></td>
<td>World Intellectual Property Organization</td>
</tr>
<tr>
<td><strong>WHO</strong></td>
<td>World Health Organization</td>
</tr>
<tr>
<td><strong>WMO</strong></td>
<td>World Meteorological Organization</td>
</tr>
<tr>
<td><strong>WSSD</strong></td>
<td>World Summit on Sustainable Development</td>
</tr>
<tr>
<td><strong>ZDHC</strong></td>
<td>Zero Discharge of Hazardous Chemicals</td>
</tr>
</tbody>
</table>
## Contents

**Introduction: chemicals and waste in the broader sustainable development context**  
xxxii

1/ The global context for the sound management of chemicals and waste  
2/ Milestones in international chemicals and waste management  
3/ Opportunities to link international policy agendas  
4/ Overview of the Global Chemicals Outlook II  

References  

---

**Key messages for policymakers: a call for more ambitious action at all levels**  
16

---

**I. The evolving chemicals economy: status and trends relevant for sustainability**  
22

1/ The chemical industry  
2/ Trends in production and sales of specific chemicals  
3/ Megatrends and chemical-intensive industry sectors: risks and opportunities  
4/ Global supply chains, chemicals in products, and circularity  
5/ Chemical pollution: emissions, releases and wastes  
6/ Concentrations of chemicals in the environment and humans  
7/ Environmental, health and social effects of chemicals  
8/ The economic benefits of action and the costs of inaction  

References  

II. Where do we stand in achieving the 2020 goal – assessing overall progress and gaps

1/ International agreements and frameworks on chemicals and waste
2/ Reporting schemes and indicators under international agreements and frameworks
3/ Achieving the 2020 goal: what do we know?
4/ Emerging policy issues and other issues of concern
5/ Other issues where emerging evidence indicates a risk
6/ Overall progress towards the 2020 goal: what have we learned?
   Annex: Other issues where emerging evidence indicates a risk

References

III. Advancing and sharing chemicals management tools and approaches: taking stock, looking into the future

1/ Hazard assessment: progress in information generation and hazard characterization
2/ Exposure assessment: benefiting from internationally available resources
3/ Risk assessment: opportunities to improve and accelerate progress
4/ Risk management decision-making: making it work in all countries
5/ Assessment of chemical and non-chemical alternatives: focusing on solutions
6/ Chemical risk management in facilities and during production
7/ Approaches to sustainability assessment

References
IV.  **Enabling policies and action to support innovative solutions**  
1/ Envisioning and shaping the future of chemistry  
2/ Green and sustainable chemistry education: nurturing a new generation of chemists  
3/ Strengthening sustainable chemistry technology innovation and financing  
4/ Evolving and new business models  
5/ Fiscal incentives to advance sound chemicals management and sustainable chemistry  
6/ Sustainable supply chain management for chemicals and waste in the life cycle  
7/ Sustainability metrics and reporting: measuring progress, strengthening accountability  
8/ Empowering and protecting citizens, workers and consumers  
References  

V.  **Scaling up collaborative action under the 2030 Agenda for Sustainable Development**  
1/ The 2030 Agenda for Sustainable Development: an integrated framework for action  
2/ Strengthening collaborative action on chemicals and waste in line with the 2030 Agenda  
3/ Engaging all sectors and actors in chemicals and waste management beyond 2020  
References  

Index
List of Figures

Introduction: chemicals and waste in the broader sustainable development context

1/ The global context for the sound management of chemicals and waste

Figure 1.1 Share of the volume of chemicals consumed in the European Union in 2016 by hazard categories 3

2/ Milestones in international chemicals and waste management

Figure 2.1 Key milestones in global sustainable development governance (which also included the sound management of chemicals and waste) 6
Figure 2.2 The Sustainable Development Goals 8

3/ Opportunities to link international policy agendas

Figure 3.1 The waste hierarchy, sustainable materials management and the circular economy 12

I. The evolving chemicals economy: status and trends relevant for sustainability

1/ The chemical industry

Figure 1.1 Total chemical industry revenues, 2002-2016 (US dollars billion) 25
Figure 1.2 Chemical sales by geographic region, 2017 (EUR billion) 25
Figure 1.3 Growth in production volume, 2000-2017 26
Figure 1.4 Global chemical industry capacity growth in million tonnes, 2000-2017 27
Figure 1.5 Projected growth in world chemical sales, 2017-2030 28
Figure 1.6 Projection of annual production growth in the chemical industry by region, 2015-2022 (per cent change per year) 28
Figure 1.7 Value chain of the chemical industry: from extraction to finished products 29
Figure 1.8 Chemical segments in the global value chain 30
Figure 1.9 Trends in materials extraction, financial value creation and greenhouse gas emissions (1900-2050) 31
Figure 1.10 The global material footprint: extracted resources by key societal needs and consumables, 2015 (billion tonnes) 32
Figure 1.11 Resource extraction by the chemical sector and related chemicals production, 2013 in millions of tonnes (Mt) 33
Figure 1.12 Feedstocks for chemical production, 2000-2040 (quadrillion British thermal units [BTUs]) 34
Figure 1.13 Share of Asian bio-based polymer production capacity in global production, 2016 (per cent) 35
2/ Trends in production and sales of specific chemicals

Figure 2.1 Global chemical shipments by segment in 2006, 2011 and 2016 (US dollars billion) 42
Figure 2.2 Production of DDT by decade since 1940 44
Figure 2.3 Value of global pesticide trade, 1970-2016 (US dollars billion) 47
Figure 2.4 Global and regional sales of crop protection products in 2015 (US dollars million) 48
Figure 2.5 Worldwide total prescription drug sales (US dollars billion) and growth rate (per cent), 2010-2024 49
Figure 2.6 Geographical breakdown (by main markets) of sales of new medicines launched in the period 2012-2017 49
Figure 2.7 Global flame retardants market by chemistry, 2017 51
Figure 2.8 Global lead consumption by product, 2018 52
Figure 2.9 Global mercury demand by sector, including uncertainties, 2005-2015 (tonnes) 53
Figure 2.10 Asbestos mine production in the largest producer countries, 2010-2017 (tonnes) 57
Figure 2.11 Global and regional plastics production, 1950-2050 (million tonnes) 57
Figure 2.12 Distribution of global plastics production, 2017 (per cent) 58
Figure 2.13 Uses of plastic: main downstream sectors, 2017 (per cent) 59
Figure 2.14 Global bioplastics production capacity, 2017-2023 (thousand tonnes) 60

3/ Megatrends and chemical-intensive industry sectors: risks and opportunities

Figure 3.1 Growth of basic chemical production capacity vs. population growth, 1990-2030 63
Figure 3.2 Middle class dominance in 2030 (in billions) 64
Figure 3.3 The growth of e-commerce, 2016-2021 65
Figure 3.4 Growth of the urban population by city size, 1990-2030 67
Figure 3.5 Trends in the number of loss-relevant natural events, 1980-2016 68
Figure 3.6 Global e-waste generated by volume and per inhabitant, 2014-2021 71
Figure 3.7 Use of pesticides per area of cropland, kg/ha, sum 2006-2016 73
Figure 3.8 Global average annual net capacity additions by type of energy (gigawatts), 2010-2016 and 2017-2040 75
Figure 3.9 Growth of clothing sales and comparison with declining clothing utilization 77

4/ Global supply chains, chemicals in products, and circularity

Figure 4.1 Illustration of the complexity of global supply chains: the case of an electronic product 79
Figure 4.2 Relative scale of exports of toys from China by importing market 79
Figure 4.3 Global supply chain in the textile sector 80
Figure 4.4 Relationship between global value chains, product life cycles, product supply chains and chemical supply chains in a linear economy 82
Figure 4.5 Chemicals in an office chair 83
Figure 4.6 Variations in chemical content in a body lotion and in vinyl flooring (per cent) 84
Figure 4.7  Simplified material flow of a circular economy in a global scale with health and environmental risks 87
Figure 4.8  Unintended residues found in recyclable waste paper (mg/kg) 87
Figure 4.9  Concept-to-production (C2P) global regulations by subject, cumulative total 89

5/ Chemical pollution: emissions, releases and wastes

Figure 5.1  The value chain of the chemical industry, with emissions/releases to the environment 93
Figure 5.2  On-site air releases in the United States reported to the Toxics Release Inventory (TRI), 2006-2016 (million pounds) 95
Figure 5.3  National/regional PCDD/PCDF releases per unit area 97
Figure 5.4  Potential sources of chemical water pollution 98
Figure 5.5  On-site hazardous surface water discharges in the United States reported to the Toxics Release Inventory (TRI) (millions of pounds), 2006-2016 99
Figure 5.6  Global releases of plastic and microplastic waste to oceans (million tonnes per year) 102
Figure 5.7  Average active ingredient application rates over time as a function of the decade of introduction, 1950s-2000s 103
Figure 5.8  Global glyphosate use, 1994-2014 (tonnes) 104
Figure 5.9  Contributors to VOC emissions to ambient air in Los Angeles, California, 2010 106
Figure 5.10  Spatial distribution of releases of linear alkylbenzene sulphonate (LAS) due to household emissions in Asia, in mg/m²/day 107
Figure 5.11  Waste generation by level of national income (US dollars) 109
Figure 5.12  Composition of municipal solid waste in Sub-Saharan Africa (per cent) 110
Figure 5.13  Recycled and composted waste as a share of total municipal waste in OECD countries (per cent), 2013 111
Figure 5.14  Global hazardous waste generation in 2009 (thousand tonnes) 113
Figure 5.15  Sources of hazardous waste in the United States by sector, 2011 (per cent of volume) 113
Figure 5.16  Sources of hazardous waste in EU countries by sector, 2015 (per cent) 114
Figure 5.17  Chemical accidents reported in news media in OECD, non-OECD and EU countries, October 2016-September 2017 117
Figure 5.18  Number of chemical accidents in OECD countries with significant releases to the environment 118

6/ Concentrations of chemicals in the environment and humans

Figure 6.1  Value chain of the chemical industry, showing emissions and concentrations 121
Figure 6.2  Exposure pathways 122
Figure 6.3  Links between the near-field environment and compartment of entry, the far-field environment, and the human body 123
Figure 6.4  Trends in DDT concentrations in air, and ratios between DDT and total DDTs (pg/m³), in Hedo, Japan, 2009-2013 127
Figure 6.5  Trends in concentrations of PCBs in Košetice, Czech Republic (pg/m³), 1996-2013 127
Figure 6.6  Global atmospheric concentrations of polybrominated diphenyl ethers (PBDEs) and of organophosphate esters (OPEs) and other novel flame retardants (FRs) at four location types: polar, background, rural and urban, 2014 129
Figure 6.7  Number of pharmaceuticals detected in surface water, groundwater, tap water and/or drinking water 132
Figure 6.8  Concentrations of polybrominated diphenyl ethers (PBDEs) in surface soil by land use category (ng/g) 134
Figure 6.9  Mercury concentrations in large lake trout collected from the East Arm of Great Slave Lake, Canada (μg/g), 1992-2012 137
II. Where do we stand in achieving the 2020 goal – assessing overall progress and gaps

2/ Reporting schemes and indicators under international agreements and frameworks

Figure 2.1 Compliance with national reporting obligations, 2016: Basel and Stockholm Conventions 231
Figure 2.2 Historical evolution of general compliance with national reporting obligations: Basel and Stockholm Conventions, 2001-2015 232
Figure 2.3 Average national reporting rate 2001-2016, by category of countries (developed/developing) and by regions: Basel and Stockholm Conventions 232

3/ Achieving the 2020 goal: what do we know?

Figure 3.1 Parties to the Basel Convention, as at January 2019 244
Figure 3.2 Basel Convention implementation: Parties which have used the option to adopt a national definition of hazardous waste, as at January 2019 244
Figure 3.3 Parties to the Rotterdam Convention, as at January 2019 245
Figure 3.4 Parties to the Stockholm Convention, as at January 2019 246
List of Figures

Figure 3.5 Countries with National Implementation Plans (NIPs) under the Stockholm Convention, as at January 2019 247
Figure 3.6 Parties to the Minamata Convention, as at January 2019 248
Figure 3.7 Countries which have undertaken Minamata Initial Assessments (MIAs), as at January 2019 249
Figure 3.8 Parties with National Action Plans (NAPs) for artisanal and small-scale gold mining, as at January 2019 249
Figure 3.9 Countries with core capacities for chemicals under the International Health Regulations (2005), 2018 251
Figure 3.10 National profiles to assess the chemicals and management infrastructure, 2018 260
Figure 3.11 Engagement of sectors in coordination mechanisms, comparing results for 2009-2010 and 2011-2013 261
Figure 3.12 Global GHS implementation status, 2018 264
Figure 3.13 Pollutant Release and Transfer Registers, 2018 265
Figure 3.14 Progress in environmental and health monitoring, comparing results for 2009-2010 and 2011-2013 266
Figure 3.15 Countries with pesticide legislation, according to FAO data collected in the context of the Code of Conduct, February 2018 271
Figure 3.16 Countries that have banned the use of asbestos, August 2018 271
Figure 3.17 Global status of phasing out lead in gasoline, March 2017 272
Figure 3.18 Trends the in use of IOMC tools for risk reduction for the reporting period 2011–2013 272
Figure 3.19 Existence and distribution of poisons centres, September 2017 273
Figure 3.20 Trends in private sector financial support comparing results for 2009-2010 and 2011-2013 276
Figure 3.21 Trends in industry participation in multi-stakeholder committees comparing results for 2009-2010 and 2011-2013 276
Figure 3.22 Countries with a chemical industry which have implemented the Responsible Care® programme as of March 2017 277
Figure 3.23 Resource allocations for chemicals and waste by GEF round, 1994-2018 278
Figure 3.24 GEF-6 projects by chemical group 279
Figure 3.25 Overview of the Quick Start Programme since 2006 280
Figure 3.26 Increase in percentage of developing country governments with development assistance programmes that address chemicals comparing results for 2009-2010 and 2011-2013 281
Figure 3.27 Comparison of results of the 2015 ICCA progress report with the 2009 baseline for SAICM indicators under capacity building and technical cooperation 282
Figure 3.28 Selected SAICM indicators, comparing results for 2009-2010 and 2011-2013 287
Figure 3.29 Progress against objectives since the first reporting period, by region for the reporting period 2011–2013 (per cent) 288

4/ Emerging policy issues and other issues of concern

Figure 4.1 Economic costs of childhood lead exposure in low- and middle-income countries (percentage of gross domestic product) 294
Figure 4.2 Status of lead paint regulation worldwide, as reported in 2017 295
Figure 4.3 The life cycle of electronic and electrical products 296
Figure 4.4 Percentage of the world population and number of countries covered by e-waste legislation in 2014 and 2017 298
Figure 4.5 Discomfort or illness experienced during or after pesticide application in Mozambique 300
Figure 4.6 Conversion process from chemical products to articles in the supply chain 303
Figure 4.7 Schematic overview of the structure categories of identified PFASs 308
Figure 4.8  Estimated annual releases of PFCAs from PFOA production sites (left) and fluoropolymer production sites (right) in the United States, Western Europe and Japan (purple), as well as in China, Russia, Poland and India (orange) (t/yr), 1951-2015

Figure 4.9  Pathways of antibiotics for human and veterinary use in the environment

Figure 4.10  Milestones in the development of the EDC field, 1958-2013

III. Advancing and sharing chemicals management tools and approaches: taking stock, looking into the future

1/ Hazard assessment: progress in information generation and hazard characterization

Figure 1.1  From risk assessment to risk management

Figure 1.2  Graphical representation of a chemical category and some approaches for filling data gaps

Figure 1.3  Testing and assessment based on the Adverse Outcome Pathway (AOP) concept

2/ Exposure assessment: benefiting from internationally available resources

Figure 2.1  Aggregate (left) and cumulative (right) exposure

Figure 2.2  Transfer fractions to near-field and far-field compartments and the corresponding product intake fraction for phenoxyethanol used as a preservative at a concentration of 0.86 per cent in a hand lotion

4/ Risk management decision-making: making it work in all countries

Figure 4.1  Hazard pictograms according to the GHS

Figure 4.2  Risk assessment and socio-economic assessment (SEA)

6/ Chemical risk management in facilities and during production

Figure 6.1  Stakeholders in the change of ownership of hazardous facilities

7/ Approaches to sustainability assessment

Figure 7.1  Conceptual relationships of the main chemical management tools

Figure 7.2  General structure of the life cycle assessment (LCA) framework

Figure 7.3  Elements of a comprehensive framework to evaluate global chemical supply chain impacts on humans and the environment
IV. Enabling policies and action to support innovative solutions

1/ Envisioning and shaping the future of chemistry

Figure 1.1 Examples of how chemistry contributes to industries expected to play important roles in the future 506
Figure 1.2 Dimensions of a chemical enterprise: towards sustainability 509
Figure 1.3 Market size of the global green chemistry industry, 2015-2020 (US dollars billion) 510
Figure 1.4 Global green chemicals market by region (US dollars billion), 2011-2020 511
Figure 1.5 The four industrial revolutions 512
Figure 1.6 Overview of the implications of digitalization in the chemical industry 513

2/ Green and sustainable chemistry education: nurturing a new generation of chemists

Figure 2.1 Number of papers published on GSCE, 1998-July 2018, concerning green chemistry education or sustainable chemistry education 518
Figure 2.2 Number of papers published on GSCE, 1998-July 2018 518
Figure 2.3 Steps to promote GSCE 520

3/ Strengthening sustainable chemistry technology innovation and financing

Figure 3.1 Innovation ecosystem model 525
Figure 3.2 Technology innovation chain and key enabling factors 526
Figure 3.3 Stage of technology readiness and the Valley of Death 527
Figure 3.4 Venn diagram of incubator and accelerator characteristics 534
Figure 3.5 Venturing tools supporting start-ups at different innovation phases 534
Figure 3.6 Start-up development stages and typical investors along the innovation chain (Swedish krona thousand) 536
Figure 3.7 Chemical industry leaders´ view of the evolution of the intensity of collaboration with other stakeholders 537
Figure 3.8 New collaboration approaches in the chemical industry 539
Figure 3.9 Policy interventions that foster technology innovation 540

4/ Evolving and new business models

Figure 4.1 Traditional business models vs. Chemical Leasing 544
Figure 4.2 Visible and hidden chemicals management costs 545
Figure 4.3 Global growth of eco-industrial parks (EIPs) 546
Figure 4.4 Eco-industrial parks’ sources of revenue 547
Figure 4.5 Evolution of a social enterprise 552

5/ Fiscal incentives to advance sound chemicals management and sustainable chemistry

Figure 5.1 Marginal cost of reducing the use of trichloroethylene (TCE) in metal degreasing 557
Figure 5.2 Effects of differentiated taxation on quantities of pesticides sold in Norway, 1997-2008 559
6/ Sustainable supply chain management for chemicals and waste in the life cycle

Figure 6.1 Interface of demand and supply in driving the sustainability of chemicals in the supply chain

Figure 6.2 Sustainable Supplier Relationship Management (SSRM) practices

7/ Sustainability metrics and reporting: measuring progress, strengthening accountability

Figure 7.1 Share of the top 100 companies in 34 countries (N100) and of the world’s 250 largest companies providing corporate responsibility reports (per cent), 1993-2017

Figure 7.2 Snapshot of Sumitomo’s Corporate Social Responsibility Report: work-related incident rate (per cent), 2011-2015

Figure 7.3 ZDHC and PUMA’s rates of compliance with MRSL parameters in wastewater (per cent), 2017

Figure 7.4 Average percentage of points across four Chemical Footprint Project (CFP) pillars scored by small, medium and large companies selling only articles

8/ Empowering and protecting citizens, workers and consumers

Figure 8.1 DOZN scoring example

Figure 8.2 Citizen science project to monitor the concentration of neonicotinoids in honey, November 2012 and February 2016

Figure 8.3 Human rights impacts by life cycle stage, information received between 2012-2017

V. Scaling up collaborative action under the 2030 Agenda for Sustainable Development

1/ The 2030 Agenda for Sustainable Development: an integrated framework for action

Figure 1.1 The three dimensions of sustainability

Figure 1.2 Linkages between chemicals and waste and the SDGs

Figure 1.3 Alignment of the Dow 2025 Sustainability Goals with the SDGs

Figure 1.4 Building blocks for a collaborative society

Figure 1.5 A multisectoral collaboration model to achieve transformative change
List of Tables

Introduction: chemicals and waste in the broader sustainable development context

1/  The global context for the sound management of chemicals and waste

Table 1.1  Chemicals and waste in the 2030 Agenda for Sustainable Development: SDG Targets 3.9 and 12.4 2

I.  The evolving chemicals economy: status and trends relevant for sustainability

2/  Trends in production and sales of specific chemicals

Table 2.1 Total global chemical shipments, 2016 and 2017 (US dollars billion) 42
Table 2.2 Overview of estimated total production of PCBs 43
Table 2.3 Global production capacity for petrochemicals, 2016 44
Table 2.4 Evolution of global production capacity for primary petrochemical building blocks (kg per capita) 45
Table 2.5 Global manufacture of pesticide active ingredients by region, 2008-2016 (thousand kg) 46
Table 2.6 Top 10 products used on major crops in the United States by volume, 1968 and 2016 47
Table 2.7 Geographic distribution of fluoropolymer consumption in 2015 in tonnes (per cent share) 50
Table 2.8 Global refined lead production and usage (thousand tonnes), 2013-2018 52
Table 2.9 Global mercury supply, 2015 (tonnes) 54
Table 2.10 Cadmium: refinery production by country, 2012-2016 (tonnes) 55
Table 2.11 World production of rare earth mineral concentrates (thousand tonnes) and total estimated increase (per cent), 1990-2015 56

3/  Megatrends and chemical-intensive industry sectors: risks and opportunities

Table 3.1 Matrix analysis of megatrend studies 62
Table 3.2 World population prospects (millions) 63
Table 3.3 Major end markets for four primary commodity chemical groups 69
Table 3.4 End markets for chemicals 69

4/  Global supply chains, chemicals in products, and circularity

Table 4.1 Actors, main impact drivers and exposure over the product life cycle of toys 81
Table 4.2 Examples of studies identifying unintended chemical contaminants in products 85
5/ Chemical pollution: emissions, releases and wastes

Table 5.1 Hazardous and non-hazardous wastes from six African countries (tonnes/year), 2012
Table 5.2 Hazardous waste generation in selected countries, 2014 (tonnes)
Table 5.3 Resource efficiency in the chemical industry: ratio of products and waste generation

7/ Environmental, health and social effects of chemicals

Table 7.1 Total number of agents and POPs classified by the IARC Monographs per group (Volumes 1-123)
Table 7.2 Chemicals identified by Grandjean and Ladrigan (2014) as being toxic to the human nervous system, 2006 and 2013

II. Where do we stand in achieving the 2020 goal – assessing overall progress and gaps

1/ International agreements and frameworks on chemicals and waste

Table 1.1 Multilateral agreements related to the sound management of chemicals and waste

2/ Reporting schemes and indicators under international agreements and frameworks

Table 2.1 IOMC Indicators and linkages to other policy instruments
Table 2.2 SDGs 3, 6, 11 and 12 with targets, indicators, custodian and partner agencies, and linkages to OOG elements

3/ Achieving the 2020 goal: what do we know?

Table 3.1 Estimates of progress made towards elimination of PCBs use per UN region, 1990-2015
Table 3.2 Examples of regional institutions and initiatives addressing chemicals and waste in the African region
Table 3.3 Examples of regional institutions and initiatives addressing chemicals and waste in the Asia and the Pacific region
Table 3.4 Examples of regional institutions and initiatives addressing chemicals and waste in Europe
Table 3.5 Examples of regional institutions and initiatives addressing chemicals and waste in Latin America and the Caribbean
Table 3.6 Examples of regional institutions and initiatives addressing chemicals and waste in North America
Table 3.7 Examples of regional institutions and initiatives addressing chemicals and waste in the West Asia region
Table 3.8 Examples of science policy bodies and mechanisms
Table 3.9 Stakeholder perceptions of the degree of success regarding prevention of illegal international traffic in chemicals and waste from 2006-2015, asked between 14 November 2016 to 4 January 2017
Table 3.10 Stakeholder perceptions of the degree of success in achieving OPS objectives from 2006-2015, asked between 14 November 2016 to 4 January 2017
III. Advancing and sharing chemicals management tools and approaches: taking stock, looking into the future

1/ Hazard assessment: progress in information generation and hazard characterization

Table 1.1 Health hazards and environmental hazards – classes for global hazard classification

4/ Risk management decision-making: making it work in all countries

Table 4.1 Forms of standards complemented with international examples relevant to chemicals and waste management

5/ Assessment of chemical and non-chemical alternatives: focusing on solutions

Table 5.1 A functional substitution approach for chemicals in products and processes
Table 5.2 Components of an alternatives assessment
Table 5.3 Examples in the literature referring to potential regrettable substitution
Table 5.4 Examples of treaties, regulatory actions and non-regulatory initiatives with provisions for alternatives assessment or substitution

6/ Chemical risk management in facilities and during production

Table 6.1 Selected activities of organizations engaged in addressing chemical accidents

IV. Enabling policies and action to support innovative solutions

2/ Green and sustainable chemistry education: nurturing a new generation of chemists

Table 2.1 Sustainable chemistry teaching: laboratory content

3/ Strengthening sustainable chemistry technology innovation and financing

Table 3.1 Institutional venturing tools
Table 3.2 Potential private investors for sustainable chemistry start-ups
Table 3.3 Examples of investments in sustainable chemistry start-ups by different investors
Table 3.4 The corporate approach to start-up development
Table 3.5 Examples of push and pull policies to advance sustainable chemistry innovation
5/ Fiscal incentives to advance sound chemicals management and sustainable chemistry

Table 5.1 Types of market-based instruments and examples of their application to chemicals management 556

6/ Sustainable supply chain management for chemicals and waste in the life cycle

Table 6.1 From traditional to green and biomimetic chemistry technologies 574

V. Scaling up collaborative action under the 2030 Agenda for Sustainable Development

1/ The 2030 Agenda for Sustainable Development: an integrated framework for action

Table 1.1 Indicative mapping of IOMC participating organizations' activities on the SDGs for sound chemicals and waste management 636

2/ Strengthening collaborative action on chemicals and waste in line with the 2030 Agenda

Table 2.1 Integrating chemicals and waste management, and green and sustainable chemistry innovation, in relevant economic sectors: some opportunities 644
Table 2.2 Examples of opportunities for the contribution of international chemicals and waste agreements across economic sectors 645
Table 2.3 Example of a results chain to minimize adverse impacts 650
List of Boxes

1. The evolving chemicals economy: status and trends relevant for sustainability

1/ The chemical industry

Box 1.1 Women in leadership positions in the chemical industry 36
Box 1.2 The benefits of thorough due diligence during mergers and acquisitions 39

2/ Trends in production and sales of specific chemicals

Box 2.1 Microplastics 60

3/ Megatrends and chemical-intensive industry sectors: risks and opportunities

Box 3.1 Lead-acid batteries: avoiding future legacies 75

4/ Global supply chains, chemicals in products, and circularity

Box 4.1 An example of challenges related to the interface of chemicals, waste and circularity: the phthalate plasticizer DEHP in PVC 88

5/ Chemical pollution: emissions, releases and wastes

Box 5.1 Outcomes of the effectiveness evaluation of the Stockholm Convention 96
Box 5.2 Releases of chemicals used in fracking 101

6/ Concentrations of chemicals in the environment and humans

Box 6.1 Bioaccumulation and biomagnification 122
Box 6.2 Concentrations of legacy chemicals in water bodies: the Mariana and Kermadec trenches and Lake Geneva 131

7/ Environmental, health and social effects of chemicals

Box 7.1 Coral reefs are under threat from chemical pollution 148
Box 7.2 Endocrine-disrupting chemicals 153

8/ The economic benefits of action and the costs of inaction

Box 8.1 Externalities: the differences between market prices and social costs 165
Box 8.2 Current methodological developments: SACAME 168
Box 8.3 Utility, economic value and economic cost 169
II. Where do we stand in achieving the 2020 goal – assessing overall progress and gaps

1/ International agreements and frameworks on chemicals and waste

Box 1.1 The elements of the Strategic Approach to International Chemicals Management 225

2/ Reporting schemes and indicators under international agreements and frameworks

Box 2.1 The reporting mechanism for the WHO IHR 233
Box 2.2 SAICM indicators of progress 236
Box 2.3 The SAICM Overall Orientation and Guidance (OOG) 237

3/ Achieving the 2020 goal: what do we know?

Box 3.1 Synergies across multilateral treaties on chemicals and waste 250
Box 3.2 SAICM Implementation Plan for Guyana 261
Box 3.3 Potential considerations for the selection of future issues of global concern 268
Box 3.4 Identified challenges in creating a coherent global knowledge base: lessons for strengthening the science-policy interface 268
Box 3.5 SAICM independent evaluation: on-line survey of stakeholders 289

4/ Emerging policy issues and other issues of concern

Box 4.1 Preventing suicides attributable to pesticides through regulatory measures in Sri Lanka 301
Box 4.2 The Higg Index: advancing sustainability in the apparel industry 304
Box 4.3 Helping doctors to make informed prescription choices 313
Box 4.4 First standardized test method specifically for nanomaterials adopted by the OECD 315

III. Advancing and sharing chemicals management tools and approaches: taking stock, looking into the future

1/ Hazard assessment: progress in information generation and hazard characterization

Box 1.1 The eChemPortal 393
Box 1.2 The European Chemicals Agency's longer-term vision for improving access to information 394

2/ Exposure assessment: benefiting from internationally available resources

Box 2.1 Human exposure to chemicals – environmental pathways 397
Box 2.2 Programmes to monitor chemicals in humans and the environment 398
Box 2.3 OECD Emission Scenario Documents (ESDs) 402
3/ Risk assessment: opportunities to improve and accelerate progress

Box 3.1 Canada’s Chemicals Management Plan 408
Box 3.2 The WHO Human Health Risk Assessment Toolkit 410
Box 3.3 The OECD Environmental Risk Assessment Toolkit 410
Box 3.4 Assessing exposure to chemical mixtures: WHO and EFSA activities 412
Box 3.5 The WHO One Health initiative 413
Box 3.6 Solution-focused risk assessment 415

4/ Risk management decision-making: making it work in all countries

Box 4.1 Tools used by retailers to identify hazardous chemicals in their products and to select safer and greener alternatives 431
Box 4.2 Decision-making for industrial chemicals: the IOMC Toolbox 434

5/ Assessment of chemical and non-chemical alternatives: focusing on solutions

Box 5.1 Dental amalgam – informed substitution in developing countries 440
Box 5.2 Proactive substitution by frontrunners: safer alternatives for brominated flame retardants in the electronics sector 442
Box 5.3 Replacing highly hazardous pesticides through Integrated Pest Management and non-chemical alternatives 444
Box 5.4 The mix of regulatory and non-regulatory policies to support informed substitution 447
Box 5.5 The importance of policies that include technical support structures: chlorinated solvent substitution 448
Box 5.6 Substitution of methyl bromide: the importance of having a range of alternatives and stakeholder engagement 450
Box 5.7 Mercury-free hospitals: the importance of participatory substitution programmes and alternative technology replacements 451

6/ Chemical risk management in facilities and during production

Box 6.1 Lessons learned from Natech accidents triggered by Hurricane Harvey 459
Box 6.2 Formalizing artisanal and small-scale gold mining 466

IV. Enabling policies and action to support innovative solutions

1/ Envisioning and shaping the future of chemistry

Box 1.1 The 12 Principles of Green Chemistry 508

2/ Green and sustainable chemistry education: nurturing a new generation of chemists

Box 2.1 Examples of universities offering courses in green and sustainable chemistry 517
Box 2.2 Green chemistry and sustainability in professional education and training courses: a case study from Brazil 519
Box 2.3 The CHEM21 online learning platform

3/ Strengthening sustainable chemistry technology innovation and financing

Box 3.1 Recommended actions for universities in low- and middle-income countries facing the challenge of transforming themselves into third generation universities
Box 3.2 Insights from entrepreneurs on challenges for sustainable chemistry start-ups
Box 3.3 Selected sustainable chemistry awards and pitching events targeting start-up
Box 3.4 Open collaborations in sustainable chemistry innovation

4/ Evolving and new business models

Box 4.1 Chemical Leasing in a middle-income country: wastewater treatment in Colombia
Box 4.2 The Shanghai Chemical Industry Park
Box 4.3 Ocean Sole: a social enterprise in Kenya

5/ Fiscal incentives to advance sound chemicals management and sustainable chemistry

Box 5.1 Shifting taxes from labour to resource use and pollution
Box 5.2 Risk-based pesticide taxation in Norway and Denmark
Box 5.3 The fertilizer subsidy programme in India
Box 5.4 Chemical taxes on consumer products in Denmark and Sweden
Box 5.5 Different effects of charges on plastic bags in Ireland and South Africa
Box 5.6 The waste electric and electronic equipment (WEEE) recycling fund in China

6/ Sustainable supply chain management for chemicals and waste in the life cycle

Box 6.1 Examples of chemical sustainability initiatives in the retail sector
Box 6.2 Downstream sector sustainable supply chain initiatives addressing chemicals of concern
Box 6.3 Together for Sustainability: chemical industry collaboration with suppliers to advance sustainability
Box 6.4 Strengthening information flows between the chemical industry to downstream customers
Box 6.5 The Circular Economy Package
Box 6.6 The Design Thinking approach to advance sustainability

7/ Sustainability metrics and reporting: measuring progress, strengthening accountability

Box 7.1 Johnson’s Greenlist™ Programme
Box 7.2 Sustainability information of relevance to the financial sector

8/ Empowering and protecting citizens, workers and consumers

Box 8.1 Excerpts from paragraph 15 of the SAICM Overarching Policy Strategy (OPS)
Box 8.2 The US EPA’s Chemical Access Data Tool
Box 8.3 Examples of mobile applications for disseminating chemical information
Box 8.4 Cases of human rights protection in matters of chemicals and waste
V. Scaling up collaborative action under the 2030 Agenda for Sustainable Development

1/ The 2030 Agenda for Sustainable Development: an integrated framework for action

Box 1.1 Planetary boundaries, chemicals and waste, and the 2030 Agenda: a research perspective 635

2/ Strengthening collaborative action on chemicals and waste in line with the 2030 Agenda

Box 2.1 The WHO Chemicals Road Map 643
Box 2.2 The integrated results and indicator framework under the Strategic Plan for Biodiversity 648
Introduction: chemicals and waste in the broader sustainable development context