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Item 4 of the provisional agenda*
Considerations for Beyond 2020

Analysis of Best Practices in Sustainable Chemistry

1. The secretariat has the honor to provide, in the annex to the present note, the draft report 'Analysis of Best Practices in Sustainable Chemistry (Draft, 28 February 2018)'. The draft report has been prepared by UN Environment in response to Resolution 2/7 (section II, paragraph 20-21) on sound management of chemicals and waste, adopted at the second session of the United Nations Environment Assembly in May 2016.

2. The draft report was prepared by UN Environment, Economy Division, Chemicals and Health Branch, in collaboration with the Secretariat of the Basel, Stockholm and Rotterdam Conventions. It will be finalized by 31 March 2018, as requested by Resolution 2/7. At that time, all stakeholder submissions will be placed on the web through a separate document. An advance copy this document is available upon request.

3. For any questions or comments, stakeholders are invited to contact UN Environment, Economy Division, Chemicals and Health Branch via science.chemicals@un.org by 23 March 2018.

4. The draft document has not been formally edited.

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Analysis of Best Practices in Sustainable Chemistry

Prepared in response to Resolution 2/7 on sound management of chemicals and waste, adopted at the second session of the United Nations Environment Assembly in May 2016

Draft, 28 February 2018

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Executive Summary

This report responds to a mandate provided through Resolution 2/7 on the sound management of chemicals and waste, adopted at the second session of the United Nations Environment Assembly in May 2016. The resolution, in section III, paragraph 20 to 21, requested stakeholders having relevant experience with the issue of sustainable chemistry to submit best practises by June 2018 and the Executive Director of UN Environment to prepare a report in the first quarter of 2018 analysing the information received.

Following an introduction, Section 2 of the report provides a snapshot of sustainable chemistry initiatives and actions undertaken by stakeholders, identified via desk research. It notes that the concept is widely used by stakeholders around the world. Green chemistry, a well-defined and related concept seeking to advance a new type of chemistry, is also briefly discussed.

Section 3 presents an analysis of best practices in sustainable chemistry submitted by stakeholders. The submissions address various stages of the chemical and waste life cycle and illustrate that sustainable chemistry plays a role in achieving the Sustainable Development Goals Target 12.4 on the sound management of chemicals and wastes and related aspects of Sustainable Development Goal 12 on sustainable consumption and production (e.g. resource efficiency). At the same time, best practices also address and highlight the contribution of sustainable chemistry to other Sustainable Development Goals and Targets (e.g. zero hunger, climate change). This provides an expanded and complementary view concerning the role of chemistry in achieving broader development objectives, taking into account environmental, social and economic sustainability dimensions. Given that an agreed international definition or assessment framework to identify best practises in sustainable chemistry does not exist, all submissions were taken into account and their inclusion does not imply any judgement by UN Environment.

Section 4 provides an analysis of findings from a survey undertaken by UN Environment to elicit feedback from stakeholders on the sustainable chemistry concept. Responses reveal a broad understanding and interpretation of sustainable chemistry. In response to the question how sustainable chemistry could contribute at the international level, the idea of sustainable chemistry being seen as an assessment framework that helps to analyse the contribution of chemistry to all three dimensions of sustainable development and implementation of the 2030 Sustainable Development Agenda received the strongest support. Sustainable chemistry as a new type of chemistry and/or as a destiny or end goal to be achieved were seen less favourably, but were also supported. The majority of respondents also felt that an international definition of sustainable chemistry would be valuable.

Section 5 provides a final analysis. It concludes that sustainable chemistry is an important component to achieve the sound management of chemicals and waste and therefore relevant for the discussions on chemicals and waste management beyond 2020. The concept also helps to examine the contribution of chemistry in achieving the broader 2030 Agenda Sustainable Development Goals and Targets, such as zero hunger, climate action, safe housing, workers' health, innovation, and gender equality, while addressing all three dimensions of sustainable development. However, the exact nature of sustainable chemistry, what it entails and how it can contribute needs further reflection. Given the interest of stakeholders, including many from developing countries, to further understand and possibly develop the concept further, a practical starting point could be to develop key elements, principles and characteristics of a sustainable chemistry assessment methodology and complement it with a definition, as appropriate.

1 Introduction

Resolution 2/7 on the sound management of chemicals and waste, adopted by the United Nations Environment Assembly at its second session, held on 23-27 May 2016, in section III, paragraph 20 to 21 invited "countries, international organizations and other interested stakeholders, including the private sector, having relevant experience with the issue of sustainable chemistry to submit to the United Nations Environment Programme secretariat, by 30 June 2017, best practices, indicating how these may enhance the sound management of chemicals, inter alia through the implementation of the 2030 Agenda for Sustainable Development, as well as the Strategic Approach to International Chemicals Management and chemicals- and waste-related multilateral environmental agreements". The resolution also requested the Executive Director "to prepare a report in the first quarter of 2018 analysing the information received to assist the Strategic Approach to International Chemicals Management in considering the opportunities presented by sustainable chemistry, including linkages to sustainable consumption and production policies, and the possibilities that sustainable chemistry may offer of contributing to the achievement of the 2030 Agenda".[1]

This report responds to this mandate. It provides a brief review of sustainable chemistry initiatives identified through desk research, analyses best practices in the area of sustainable chemistry submitted by stakeholders to UN Environment, and summarizes results of a UN Environment Survey on the topic, administered in 2017 through collaboration of the Chemicals and Health Branch, Economy Division, UN Environment and the Secretariat of the Basel, Rotterdam and Stockholm Conventions. The report concludes with a brief and forward-looking analysis with the aim to advance a global understanding of sustainable chemistry, as the international community is developing an approach to the sound management of chemicals and waste beyond 2020.

Since an agreed international definition or assessment framework to identify best practises in sustainable chemistry does not exist, all submissions of best practices received were considered in this report, with the exception of those which did not provide sufficient information and where no references were provided. In light of the above, references to "best practices" or sustainable chemistry initiatives mentioned in this report do not imply any judgement by UN Environment.

2 Sustainable Chemistry: A Snapshot of Initiatives and Actions

The sustainable chemistry concept has been used by a number of initiatives and a range of stakeholders for many years. This section provides a brief and non-comprehensive overview of initiatives which specifically use the term 'sustainable chemistry', identified through desk research. In this context, it should be noted that closely related activities are undertaken within the framework of, and using the term 'green chemistry', including in many developing countries and countries with economies in transition.[2] While the sustainable chemistry concept is seen to be more holistic by many (as discussed below), green

[1] *UNEA Resolution 2/7. Sound management of chemicals and waste*. UNEP/EA.2/Res.7*, section III, paragraph 20 to 21*. United Nations Environment Programme, Nairobi.

[2] Examples of green chemistry initiatives include the Royal Society of Chemistry's journal 'Green Chemistry', the International Union of Pure and Applied Chemistry's International Conferences on Green Chemistry, the Green Chemistry and Commerce Council, the United Nations Industrial Development Organization global green chemistry project funded by the Global Environment Facility, and Green Chemistry Institute of the American Chemical Society, which has chapters in more than twenty countries, including Argentina, China, India, and South Africa (RSC. (2018). *Green Chemistry*. Weblink (accessed 14 February 2018); IUPAC. (2018). *8TH IUPAC International Conference on Green Chemistry.* Weblink *(accessed 14 February 2018);* GC3. (2018). *Advancing Green Chemistry Across Sectors and Supply Chains.* Weblink *(accessed 14 February 2018)*; ACS. (2018), *ACS Green Chemistry Institute*. Weblink (accessed 22.02.2018)).

chemistry focuses on scientific aspects of chemistry and is specified through the widely cited 12 principles of green chemistry.[3] Given the focus of the UNEA resolution on sustainable chemistry, and in light of the significant number of green chemistry initiatives, this brief overview focuses on initiatives specifically referring to sustainable chemistry initiatives. Similarly, initiatives using related concepts such as "sustainability of chemistry", "sustainable chemical industry", or "sustainable chemicals", although also closely related, are also not covered.[4]

2.1 Academia and Civil Society

Academic conferences

Since 2003 and every second year, the 'International Conference on Green and Sustainable Chemistry', sponsored by a range of academic, research and other institutions around the world, is organized in different countries and regions with the aim of highlighting significant advances related to the discovery, development and application of green and sustainable chemistry and engineering leading to the betterment of the human condition.[5] Since 2016, Elsevier is holding the 'Green and Sustainable Chemistry Conference' series. Organised on an annual basis and featuring a number of speakers and participants from developing countries, the conference's objective is to bring together international researchers from academia and industry, from authorities and other institutions to communicate and share the latest developments across the broad and diverse fields of green and sustainable chemistry.[6] Conferences are also being organized in developing countries and economies in transition. For instance, the 'Asia-Oceania Conference on Green and Sustainable Chemistry', organized since 2007, has among others been hosted in India and the People's Republic of China.[7]

Academic journals

Several academic journals focus on sustainable chemistry. This includes the American Chemical Society's 'Sustainable Chemistry and Engineering' journal, founded in 2013 to address challenges of sustainability in the chemical enterprise and advance principles of green chemistry and green engineering.[8] Elsevier's 'Sustainable Chemistry and Pharmacy', launched in 2015, employs an interdisciplinary approach and aims to contribute to a better understanding of concepts related to sustainable

[3] Green chemistry has been defined as "the utilization of a set of principles that reduces or eliminates the use of generation of hazardous substances in the design, manufacture and applications of chemical products". (Anastas, P.T. and Warner, J.C. (1998). Green Chemistry: Theory and Practice. pp.11, 30. Oxford University Press. London).

[4] There are a number of initiatives using these terms, for instance the 'Road Map Document for a Sustainable Chemical Industry' (European Commission. Weblink (2013). (accessed 27.02.2018)), the 'Guide on Sustainable Chemicals' (Umwelbundesamt. (2011). Weblink (accessed 27.02.2018)), the Boston Consulting Group's 'Making a Business Case for Sustainability of Chemicals' (BCG. (2017). Weblink (accessed 27.02.2018)), and the voluntary commitment of BASF to beat pollution via a methodology to assess sustainability across the product portfolio made at the third session of the United Nations Environment Assembly (UN Environment (2017). Annex 4: #BeatPollution Voluntary Commitments from Business. United Nations Environment Programme, Nairobi.).

[5] GSC 8 Secretariat. (2018). *International Conference on Green and Sustainable Chemistry.* Weblink (accessed 14 February 2018).

[6] Elsevier. (2018). *3rd Green & Sustainable Chemistry Conference*. Weblink (accessed 14 February 2018). Abstracts submitted for the conference include a discussion of green and sustainable chemistry education in India, submitted by researchers from the People's Education Society University (Veerabhadraswarmy, M and Anilkumar, H. G. (n.d.). *Propagation of green and sustainable chemistry education in Indian context – An overview.* Weblink (accessed 27.02.2018)).

[7] The Energy and Research Institute. (2915). The 5th Asia-Oceania Conference on Green and Sustainable Chemistry. Weblink (accessed 27.02.2018); City University of Hong Kong. (2016). 6th Asia-Oceania Conference on Sustainable and Green Chemistry. Weblink (accessed 27.02.2018)

[8] ACS. (2018). *ACS Sustainable Chemistry & Engineering*. Weblink (accessed 14 February 2018).

pharmacy, including the circular economy.[9] Elsevier's journal 'Current Opinion in Green and Sustainable Chemistry' seeks to advance a better understanding where and how chemistry itself can be made more sustainable and whereby chemistry can contribute to sustainability in general.[10] In addition, numerous articles published in various scientific journals feature titles using the term sustainable chemistry, including from a developing country perspective.[11]

Curricula and research

The concept of sustainable chemistry has also been integrated in curricula of universities, under the heading of sustainable chemistry research, courses and Master's programmes. For example, the Research Institute for Sustainable Chemistry established by the National Institute of Advanced Industrial Science and Technology in Japan is engaged in research and development of sustainable chemistry since 2015.[12] Sustainable chemistry is also a research priority area at the University of Amsterdam, with a total equivalent of 90 dedicated researchers.[13] Universities offering postgraduate courses on sustainable chemistry include the University of Valencia, the University of Nottingham, the New University of Lisbon and the University of Venice.[14] As another example, the European Association for Chemical and Molecular Sciences is organizing regular European Sustainable Chemistry Awards to recognise individuals or small research groups which make an outstanding contribution to sustainable development by applying green and sustainable chemistry.[15] Universities are also the origin of start-up initiatives seeking to advance sustainable chemistry. In the context of a workshop in 2017 on 'Advancing Entrepreneurship and Start-up Initiatives for Sustainable Chemistry: Learning from Case Studies', several case examples were provided by researchers from Universities and research institutions, including from Colombia and Nigeria.[16] Moreover, universities are partnering with the private sector in the field of sustainable chemistry: In 2013, the São Paulo Research Foundation (FAPESP) and a British pharmaceutical company announced the creation of a 'Centre of Excellence for Sustainable Chemistry' in Brazil.[17]

Civil society

The International Persistent Organic Pollutants Elimination Network, comprised of several hundred participating organizations in more than hundred countries, presented a document exploring the role and potential of green chemistry and sustainable chemistry in order to inform discussions at the first meeting of the intersessional process to prepare recommendations regarding the Strategic Approach and the sound management of chemicals and waste beyond 2020.[18] On the occasion of the 'Conference on

[9] Elsevier. (2018). *Sustainable Chemistry and Pharmacy*. Weblink (accessed 14 February 2018).
[10] Elsevier. (2018). *Current Opinion in Green and Sustainable Chemistry*. Weblink (accessed 14 February 2018).
[11] Barra, R. and Gonzalez, P. Sustainable chemistry challenges from a developing country perspective: Education, plastic pollution and beyond. *Current Opinion in Green and Sustainable Cehmistry, 9:40-44*.
[12] AIST. 2018. *Research Institute for Sustainable Chemistry*. Weblink (accessed 14 February 2018).
[13] University of Amsterdam. (2018). *Suschem at the UvA*. Weblink (accessed 14 February 2018).
[14] The University of Nottingham. (2018). *Green and Sustainable Chemistry MSc.* Weblink (accessed 14 February 2018); The University of Valencia. (2018). *Master's Degree in Sustainable Chemistry.* Weblink (accessed 14 February 2018); Faculdade de Ciencias e Ecnologia. (2018). *Phd in Sustainable Chemistry*. Weblink (accessed 27.02.2018); and Ca' Foscari University of Venice. (2018). *Master's Degree Programme in Sustainable Chemistry and Technologies.* Weblink (accessed 14 February 2018).
[15] EuChems. (2017). *European Sustainable Chemistry Award.* Weblink (accessed 14 February 2018).
[16] UN Environment. (2017). Advancing Entrepreneurship and Start-up initiatives for Sustainable Chemistry: Learning from Case Studies' (UN Environment. Weblink (accessed 27.02.2018).
[17] GlaxoSmithKline. (2013). GSK to create a new Centre of Excellence for Sustainable Chemistry in Brazil. Weblink (accessed 27.02.2018).
[18] IPEN. (2017). *Beyond 2020: Green chemistry and sustainable chemistry.* Weblink (accessed 22.02.2018)

Mainstreaming Sustainable Chemistry' (Berlin, 17-18 May 2017), the International Persistent Organic Pollutants Elimination Network and Women in Europe for a Common Future presented a position paper providing recommendations relevant for the concept, supported by a large number of civil society organizations.[19]

As an example of concrete action, during the workshop on 'Advancing Entrepreneurship and Start-up Initiatives for Sustainable Chemistry: Learning from Case Studies', a non-governmental organization based in Ghana presented a project advancing organic farming.[20]

2.2 Private Sector

Initiatives using the term 'sustainable chemistry' by the private sector are being undertaken throughout the supply chain by the chemical industry, downstream industries and retailers. The chemical company Solvay, for example, dedicated itself to the achievement of five objectives "for a sustainable chemistry by 2025", framed under the headings to "contribute to society, innovate sustainable solutions, and act responsibly".[21] Dow Chemicals developed a 'Sustainable Chemistry Index' as a means of evaluating products, such as life cycle benefits and social needs. Dow Chemicals committed itself to the '2015 Goal on Sustainable Chemistry' to, among others, "increase the percentage of sales to 10 percent for products that are highly advantaged by sustainable chemistry", as assessed via the index.[22]

In the downstream textile sector, the Zero Discharge of Hazardous Chemicals Programme, which includes a collaboration of a number of brands, value chain affiliates and associations, commits itself to support the "widespread implementation of sustainable chemistry across the textile and footwear industries".[23] In the retail sector, the multinational corporation Walmart launched the 'Walmart Commitment to Sustainable Chemistry' in 2013. As part of the policy, Walmart developed a set of sustainable chemistry principles, including pledges to encourage "full ingredient transparency", advance the development of chemicals that "preserve efficacy of function while reducing toxicity", and "reduce its consumables chemical footprint" via participation in the Chemical Footprint Project. [24]

Initiatives are also underway in developing countries and economies in transition. the During the workshop on 'Advancing Entrepreneurship and Start-up Initiatives for Sustainable Chemistry: Learning from Case Studies', entrepreneurs from Brazil, India, South Africa, and Ghana shared their case examples.[25] As another example, in 2014, an investment company from South Africa, partnered with the 'Sustainable Chemistry Alliance' and the 'Bio-industrial Innovation Centre' to advance the commercialization of life science and bio-industrial technologies.[26]

[19] IPEN and WECF. (2017). *Beyond 2020: Sustainable Chemistry – NGO recommendations'*. Weblink (accessed 22.02.2018)
[20] UN Environment. (2017). *Advancing Entrepreneurship and Start-up initiatives for Sustainable Chemistry: Learning from Case Studies' (UN Environment*. Weblink (accessed 27.02.2018).
[21] Solvay. (2017). *Our objectives by 2025 for a sustainable chemistry*. Weblink (accessed 14 February 2018).
[22] Dow. (2015). 2015 Sustainability Goals: The Sustainable Chemistry Index. The Dow Chemical Company, Midland.
[23] ZDHC. (2017). *Commitment to Sustainable Chemistry Strengthens with Six New Contributors Joining ZDHC*. Weblink (accessed 14 February 2018).
[24] Walmart. (2017). *Walmart Commitment to Sustainable Chemistry*. Weblink (accessed 14 February 2018).
[25] UN Environment. (2017). *Advancing Entrepreneurship and Start-up initiatives for Sustainable Chemistry: Learning from Case Studies' (UN Environment*. Weblink (accessed 27.02.2018).
[26] Sustainable Chemistry Alliance. (2011). Sustainable Chemistry Alliance, Bioindustrial Innovation Centre to Collaborate with South African Incubator on Commercialization. Weblink (accessed 27.02.2018).

2.3 Public Sector

In 2014, SusChem, the European Technology Platform for Sustainable Chemistry, was launched as a European Union supported initiative in 2014 to revitalise and inspire European chemistry and industrial biotechnology research, development and innovation in a sustainable way. The European Union has also released a publication, which presents the objectives and main achievements of 18 selected projects funded under the 5th and 6th Framework Programmes in the fields of novel materials and sustainable chemistry.[27] Moreover, the International Sustainable Chemistry Collaborative Centre – which is also reflected in a voluntary commitment to beat pollution made by the Government of Germany at the third session of the United Nations Environment Assembly in December 2017 – was launched in 2017 as an initiative of the German Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety and the German Federal Environment Agency.[28]

In developing regions, the Government of Vietnam and the Government of Ghana, with support of the 'Deutsche Gesellschaft für Internationale Zusammenarbeit', hosted national workshops in 2017 to take stock of, and develop recommendations for action in the area of sustainable chemistry. The Governments of Ghana and Germany also joined forces, in cooperation with UN Environment and the Secretariat of the Basel, Rotterdam and Stockholm Conventions, to organize side events on sustainable chemistry at the second session of the United Nations Environment Assembly and during the 2017 Conferences of the Parties to the Basel, Rotterdam and Stockholm Conventions.[29]

2.4 Intergovernmental Organizations

In 1998, Member countries of the Organisation for Economic Co-operation and Development endorsed the implementation of an initiative on sustainable chemistry, with a focus on prevention as a means of transforming the chemicals sector.[30] The Organisation for Economic Co-operation and Development published several reports on sustainable chemistry, including on the 'Need for Research and Development Programmes in Sustainable Chemistry' and on 'Sustainable Chemistry: Evidence on Innovation from Patent Data'.[31] It is also implementing projects related to sustainable chemistry and has developed a definition of sustainable chemistry.[32] In 2017, the Organisation for the Prohibition of Chemical Weapons, in cooperation with the International Council of Chemical Associations and the International union of Pure and Applied Chemistry, organized the 'Green and Sustainable Chemistry Workshop' to develop recommendations for improving chemical safety and security within industry.[33]

[27] European Commission. (2008). Novel materials and sustainable chemistry – A decade of EU-funded research. ISBN 978-92-79-09721-8. Luxembourg: Office for Official Publications of the European Communities.
[28] ISC3. (2017). *International Sustainable Chemistry Collaborative Centre: Who we are*. Weblink (accessed 14 February 2018); UN Environment (2017). *Annex 2: #BeatPollution Voluntary Commitments from Governments*. United Nations Environment Programme, Nairobi.
[29] BRS Secretariat. (2017). *2017 COPs Side events*. Weblink (accessed 14 February 2018).
[30] OECD. (1998). *Proceedings of The OECD Workshop on Sustainable Chemistry Part1*. ENV/JM/MONO(99)19/PART1. Organization for Economic Co-operation and Development, Paris.
[31] OECD. (2002). *Need for Research and Development Programmes in Sustainable Chemistry*. ENV/JM/MONO(2002)12. Organization for Economic Co-operation and Development, Paris.
[32] OECD. (2018). *Sustainable Chemistry*. Weblink (accessed 14 February 2018); OECD. (2012). *The Role of Government Policy in Supporting the Adoption of Green/Sustainable Chemistry Innovations*. ENV/JM/MONO(2012)3. Organization for Economic Co-operation and Development, Paris.
[33] OPCW. (2017). *Experts Discuss Role of OPCW in Green and Sustainable Chemistry*. Weblink (accessed 27.02.2018).

At the UN level, in addition to two side events organized at the margins of the second session of the United Nations Environment Assembly and the Conferences to the Parties of the Basel, Rotterdam and Stockholm Conventions in 2017, the 2018-2019 Programme of work of UN Environment, approved by governments at the second session of the United Nations Environment Assembly in May 2016, includes a project concept focusing on sustainable chemistry.[34] Initial work has commenced through a workshop in 2017 on 'Advancing Entrepreneurship and Start-up Initiatives for Sustainable Chemistry: Learning from Case Studies', organized in cooperation with and the United Nations Industrial Development Organization and the International Sustainable Chemistry Collaborative Centre.[35] UN Environment and the International Sustainable Chemistry Collaborative Centre also collaborated in the organization of a side event at the 23rd Conference of the Parties to the United Nations Framework Convention on Climate Change in 2017, focusing on the potential of sustainable chemistry in contributing towards climate action.

Sustainable chemistry is also among the topics discussed in the context of the intersessional process to prepare recommendations regarding the Strategic Approach and the sound management of chemicals and waste beyond 2020, initiated at the fourth session of the International Conference on Chemicals Management in 2015. Participants at the first meeting of the intersessional process, which took place in Brazil in February 2017, discussed sustainable chemistry both in an informal dialogue and during a plenary session.[36] A thought starter developed in early 2017 by the Bureau of the fifth International Conference on Chemicals Management informed these discussions through a section on "the role of sustainable chemistry".[37] Moreover, the co-chair's summary of the meeting listed sustainable chemistry among other elements that could be taken into consideration in considering the scope of a future platform for the sound management of chemicals and waste beyond 2020.[38]

3 Analysis of Sustainable Chemistry Best Practises Submitted by Stakeholders

3.1 Data Collection and Stakeholder Responses

To facilitate submissions on best practices in the area of sustainable chemistry under the Resolution 2/7, adopted at the second session of the United Nations Environment Assembly, UN Environment sent an invitation to stakeholders of the Strategic Approach to International Chemicals Management in May 2017, focal points of the Basel, Rotterdam and Stockholm Conventions, and focal points of the Minamata Convention, including a request to disseminate the invitation to relevant stakeholders.[39] The initial deadline of 30 June 2017 was extended until 30 November 2017.

[34] UN Environment. (2016). *UNEA Resolution 2/20. Proposed medium-term strategy for 2018–2021 and programme of work and budget for 2018–2019*. UNEP/EA.2/Res.20. United Nations Environment Programme, Nairobi.

[35] The event was organized in 2017 by UN Environment and the International Sustainable Chemistry Collaborative Centre (ISC3), in partnership with the United Nations Industrial Development Organization (UNIDO), the German Chemical Society, the Freie Universität Berlin and the United Nations institute for Training and Research (UNITAR). More information is available on the website of UN Environment

[36] SAICM Secretariat. (2017). *Report of the first meeting in the intersessional process to consider the Strategic Approach and the sound management of chemicals and waste beyond 2020*. SAICM/IP.1/7. SAICM Secretariat, Geneva.

[37] SAICM Secretariat. (2017). *Thought starter for the first meeting of the intersessional process*. SAICM/IP.1/4*. SAICM Secretariat, Geneva.

[38] SAICM Secretariat. (2017). Co-chairs' summary of the discussions during the first meeting of the intersessional process to consider the Strategic Approach and the sound management of chemicals and waste beyond 2020. SAICM Secretariat, Geneva.

[39] The online form can be accessed via this weblink.

In total, 34 stakeholders responded, submitting 72 best practices (some responses included several best practises).[40] Annex A provides an overview of the institutions/organisations that submitted best practices. Annex B provides a list of the best practices, including a brief summary and the entities responsible for their implementation. The 34 responses originated from a variety of stakeholders. Most responses came from the private sector (ca. 32 %; 11 responses), followed by civil society (ca. 29 %; 10 responses); the public sector (ca. 18%; 6 responses, including 4 from developing countries and countries with economies in transition); academia (ca. 18%; 6 responses); and intergovernmental organizations (ca. 3 %; 1 response).[41] All five UN regions were represented, with more than two-thirds of the responses from the Western European and Others Region, followed by the Asia-Pacific Region and the African Region. In total, 10 responses came from developing countries or countries with economies in transition.

As shown in Figure 1, the largest share of the 72 best practices is implemented by the private sector (ca. 38 %), followed by the public sector and civil society (both ca. 19 %), academia (ca. 15 %) and intergovernmental organizations (ca. 3 %). In some cases, best practices are implemented in a joint effort by several actors (ca. 6 %). In a number of cases, best practices implemented by the private sector were submitted by a public institution/organization.

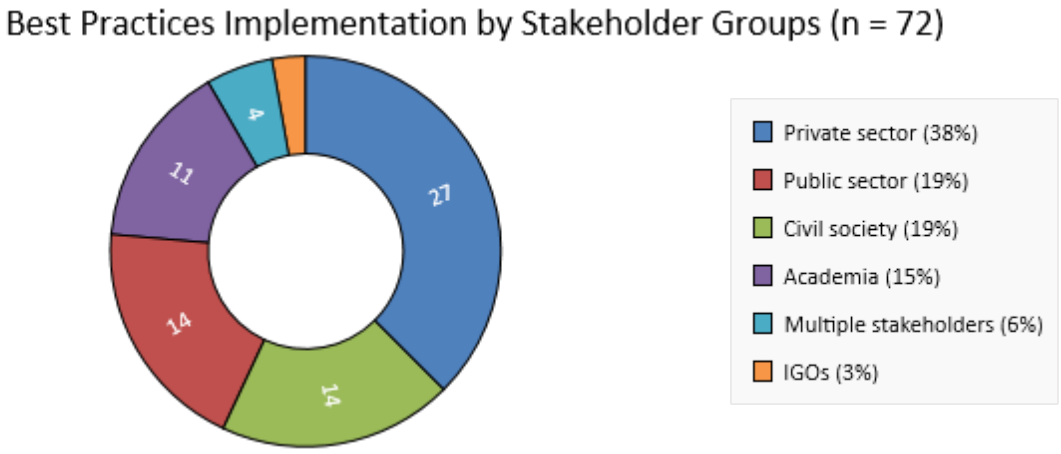

Figure 1: Best Practices Implementation by Stakeholder Groups (n = 72)

3.2 Contribution of Best Practices to the Implementation of Sustainable Development Goal Target 12.4 on the Sound Management of Chemicals and Waste

Throughout many of the submitted best practices, reference was made how they enhance specific aspects of the sound management of chemicals and waste, in line with Sustainable Development Goal Target 12.4, and the related implementation of the chemicals and waste multilateral environmental agreements and the Strategic Approach to International Chemicals Management.[42] In addition, other elements addressed by SDG 12 on Sustainable Consumption and Production, such as resource efficiency were also covered. In

[40] Some responses had to be removed as they were incomplete and/or did not contain any substantive input (i.e. in total there were more than 34 responses). In these cases, and if contact details were provided, the secretariat followed up with the respondents.

[41] Full submissions are available on request.

[42] For the five objectives and the eleven basic elements, see: SAICM Secretariat. (2006). *SAICM texts and resolutions of the International Conference on Chemicals Management*. United Nations Environment Programme, Geneva.

analysing the best practices, a number of common themes emerged, addressing all stages of the life cycle. These are noted below, including illustrative examples.

Chemical and non-chemical alternatives

A number of best practices address the substitution of chemicals of concern with safer chemicals, including in the *production process of chemicals.* For example, one best practice describes the use of an altered surfactant technology in the production of pharmaceuticals.[43] Other best practices address the substitution of chemicals with safer chemicals in *other industrial production processes*. These include the replacement of a solvent in the production of industrial labels, and the utilization of steel slag to replace strong- and amine-based reagents, for example in CO2 sequestration.[44] Several best practices address the replacement of chemicals with safer chemicals in a range of *products*, for instance in dishwasher tabs, cans, and flame retardants in insulation foam.[45]

Best practices also address the substitution of chemicals of concern with non-chemical alternatives. As regards the *production process of chemicals*, a best practice relies on bioconversion in the production of ethylene.[46] Another example illustrates the reliance on non-chemical alternatives in *products*, for example the use of biomass for the manufacture of ink.[47] Contributing to the implementation of the Minamata Convention on Mercury and the Stockholm Convention on Persistent Organic Pollutants, two best practices focus on the *replacement of equipment* with alternatives that do not require the use of mercury and polychlorinated biphenyls, respectively.[48] Best practices also address the replacement of chemicals via reliance on alternative *management approaches*, for example through agroecology.[49]

The above mentioned best practices on the introduction of chemical and non-chemical alternatives aim, among others, to protect human health and the environment, reduce water and energy consumption, and use renewable feedstocks, while at the same time reducing costs, increasing efficiencies and improving performance.

Efficient and safe use & reduction of emissions and exposure

Some best practices focus on safe and efficient use of chemicals and minimizing of chemical emissions and releases in production processes, for example by reducing the use of solvents.[50] Chemical leasing is featured in several best practices as an innovative tool, for example for gluing of boxes and for cleaning operations in the automotive sector and hotels.[51] Examples also cover regulatory initiatives and development of national action plans aiming to reduce the consumption of chemicals, for instance to

[43] Best practice submission 'Removing organic solvents from our processes'
[44] Best practice submissions 'Kilian – Functional Substitution'; and 'Utilization of steel slag as a multi-purpose sorbent for pollutants'
[45] Best practice submissions 'BASF-Trilon M'; 'CANVERA™ Polyolefin Dispersion for Can Coatings'; 'BLUEDGE™ Polymeric Flame Retardant Technology'; and 'ChemSec Marketplace'
[46] Best practice submission 'Bioconversion of crude glycerol to ethylene
[47] Best practice submission 'Prometho GmbH – GrüneTinte'
[48] Best practice submissions 'Banning of Import; Purchase and Uses of all mercury based equipment's in health sector of Nepal'; and 'Promoting PCB Free Metal Fabrication through Technology Transfer'.
[49] Best practice submission 'Replacing Chemicals With Biology: Phasing out Highly Hazardous Pesticides with Agroecology'
[50] For example best practice submissions 'PERO & SAFECHEM – Cleaning of metal parts'; 'Kilian – Functional substitution'; and 'Prometho GmbH – GrüneTinte'.
[51] Two best practice submissions entitled 'Chemical Leasing'; best practice submission 'The German Chemical Leasing Initiative'; best practice submissions 'Chemical Leasing in automotive parts industry'; and 'Chemical Leasing in Hotels'

minimize the use of biocides and plant protection products.[52] One best practice provides a tool for benchmarking companies in the selection of safer alternatives and the reduction of their use of chemicals of high concern.[53]

Other best practices focus in particular on reducing exposure of vulnerable groups, for example to protect students from lead in paint and children from heavy metals contained in toys or to reduce the exposure of workers to asbestos.[54] Other best practices seek to minimize risks and adverse impacts by ensuring the environmentally sound handling of chemicals of concern, for example via implementation of the Globally Harmonized System of Classification and Labelling, improved tracking in the transport of hazardous materials, and safe use of plant protection products.[55]

Waste management, recycling and remediation of pollution

Examples of best practices focusing on recycling/re-use include a pilot plant for polymer recycling, further development of the power to gas technology for carbon capture and utilization, and production of carbon black from non-volatile residues of the petrochemical industry.[56] Other best practices address waste management and offer end-of-the-pipe solutions to remediate pollution. Examples range from a project to reduce the burning of medical waste, over the introduction of a three-stage wastewater treatment process to separate nitrates from wastewater, to the use of a biocatalyst for the clean-up of oil spills.[57]

Cross-cutting and enabling topics

In addition to focusing on specific chemical management themes relating to various aspects of the life cycle, some best practices cut across the life cycle. Examples include the establishment of an international centre to advance sustainable chemistry and a voluntary chemical industry initiative to build capacity for sound chemicals management.[58] Other best practices seek to advance a circular economy by addressing the entire value chain. Examples include a tool implemented by major corporations to identify hazardous chemicals and alternatives, which can also be used to guide procurement, product design, standards and policies, a project measuring and disclosing data on business progress to safer chemicals, and the application of green chemistry across supply chains by developing and promoting relevant tools, policies and business practices and by fostering collaboration among relevant stakeholders.[59][60]

Many of the best practises also seek to establish an enabling environment in order to address several or all of the aspects of the life cycle . These include, but are not limited to, innovative business models (e.g. chemical leasing); assessment frameworks and guidance; regulatory measures and governance;

[52] Best practice submissions entitled '5-point Programme for Sustainable Plant Protection'; and 'Biocides – Proposal for a Concerted European Approach towards a Sustainable Use'.
[53] Best practice submission entitled 'Chemical Footprint Project'
[54] Best practice submissions 'Research based campaign for Mandatory Lead Paint Standard in Nepal'; 'Campaign for Standard of Children Toys'; and 'Banning of Import, Sale, Distribution and Uses of Asbestos in Nepal'.
[55] Best practice submissions 'Capacity Building to Foster the Sound Management of Chemicals'; and National Action Plan on Sustainable Use of Plant Protection Products'.
[56] Best practice submissions '3M – Recycling of PTFE', 'Audi – Power to Gas'; and 'Waste Heat Recovery'.
[57] Best practice submissions 'Elimination of POPs and its Sources in Nepal'; 'Süd-Chemie: Waste Water Treatment'; and 'EcoBioClean Solves a Global Problem'.
[58] Best practice submissions 'The International Sustainable Chemistry Collaborative Centre (ISC3)'; and 'Capacity Building to Foster the Sound Management of Chemicals'.
[59] Best practice submission 'Green Chemistry and Commerce Council'
[60] Best practice submissions 'GreenScreen' ; and 'Chemical Footprint Project'

awareness-raising and advocacy campaigns; capacity building, technology transfer and education; and knowledge and information.

3.3 Contribution of Best Practices to the Implementation of Other Sustainable Development Goals in the 2030 Agenda

Many best practices explicitly address other Sustainable Development Goals and Targets in addition to the 12.4 Target, presenting opportunities how sustainable chemistry contributes to the achievement of the 2030 Agenda across a broader spectrum of Sustainable Development Goals and Targets.

Sustainable Development Goal 1: No Poverty

Several best practices note contributions to improve living standards, income and access to resources of the poor and vulnerable. For example, one best practice explains how the establishment of equitable agricultural systems can help to empower farmers and local communities by reducing debt and providing livelihood opportunities.[61]

Sustainable Development Goal 2: Zero Hunger

One best practice describes how ecosystem-based approaches to pesticide and crop management can help to phase out highly hazardous pesticides, while at the same time increasing food security and providing access to safe and nutritious food.[62] Two other best practices explore integrated approaches for sustainable plant protection and sustainable use of plant protection products where they are necessary to ensure sufficient food production.[63]

Sustainable Development Goal 3: Good Health and Well-being

Examples of best practices with links to the protection of human health, including vulnerable groups, and reference to the achievement of Sustainable Development Goal 3 include an awareness-raising campaign to ban equipment containing mercury from the health sector and the use of chemical leasing to reduce the use of hazardous chemicals and protect workers during industrial cleaning in the automotive sector.[64]

Sustainable Development Goal 5: Gender Equality

Contribution to gender equality features prominently in a best practice describing how in the context of a cooperation between a chemical company and a cooperative network, a large number of women were engaged, improving their economic and social standing.[65]

[61] Best practice submission 'Replacing Chemicals With Biology: Phasing out Highly Hazardous Pesticides with Agroecology'
[62] Best practice submission 'Replacing Chemicals With Biology: Phasing out Highly Hazardous Pesticides with Agroecology'
[63] Best practice submission 'National Action Plan on Sustainable Use of Plant Protection Products' and '5-point programme for sustainable plant protection'
[64] Best practice submissions 'Banning of Import, Purchase and Uses of all mercury based equipment's in health sector of Nepal'; and 'PERO & SAFECHEM – Cleaning of metal parts'.
[65] Best practice submission 'BASF – Argan program in Morocco'.

Sustainable Development Goal 6: Clean Water and Sanitation

Best practices seeking to contribute to Sustainable Development Goal 6 include the introduction of a wastewater treatment process allowing improved removal of heavy metal nitrates, and optimization of the process for the production of carbon black via waste heat recovery, water recycling and the minimization of odour pollution.[66]

Sustainable Development Goal 7: Affordable and Clean Energy

One best practice describes how improved energy efficiency was achieved via the introduction of an innovative bio-catalytic reaction.[67] Another best practice deals with carbon capture and utilization in the automotive sector, explaining how an improved power to gas technology would allow the greenhouse gas-neutral operation of cars.[68]

Sustainable Development Goal 8: Decent Work and Economic Growth

The protection of workers' health and safety figures prominently in a number of cases, including an awareness-raising campaign targeting the phase out of asbestos use and the development of a pilot plant for polymer recycling.[69]

Sustainable Development Goal 9: Industry, Innovation and Infrastructure

By focusing on research and development, innovation and the establishment of infrastructures for sound chemicals management, most of the best practices contribute to the achievement of Sustainable Development Goal 9. Some place particular emphasis on these aspects, including the introduction of new technologies, the establishment of pilot plants, and the introduction of novel business models.[70]

Sustainable Development Goal 10: Reduced Inequalities

One of the best practices describes a fair-trade agreement between a chemical company and a cooperative network for the production of Argan oil, which allowed the cooperative to grow significantly and sell its product at fixed premium rates, with shares of the profit used to finance literacy programs and health initiatives.[71]

Sustainable Development Goal 11: Sustainable Cities and Communities:

Several best practices were framed as contributing to the provision of safe housing. For example, one best practice presents an initiative to promote the construction of 'green' buildings by promoting the use of building materials and products that are certified according to meet specified environmental standards.[72]

[66] Best practice submissions 'Süd-Chemie: Waste Water Treatment'; and 'Waste Heat Recovery'.
[67] Best practice submission 'Green and sustainable technologies to develop a greener and more energy efficient process to manufacture Pregabalin, active ingredient in the drug Lyrica'.
[68] Best practice submission 'Audi – Power to Gas (PtG)'.
[69] Best practice submissions '3M – Recycling of PTFE'; and 'Banning of Import, Sale, Distribution and Uses of Asbestos in Nepal'.
[70] For example, the best practice submissions 'Audi – Power to Gas, 3M – Recycling of PTFE'; 'Removing organic solvents from our processes, Süd-Chemie: Waste Water Treatment'; and 'Chemistry for Green Building; the German Chemical Leasing Initiative, Chemical Leasing, Chemical Leasing in automotive parts industry'.
[71] Best practice submission 'BASF – Argan program in Morocco'.
[72] Best practice submission 'Chemistry for Green Building'.

Another best practice describes the development of a grow tile for improved binding of the soil, providing increased opportunities for green spaces in urban districts.[73] Two cases explicitly address the importance of flame retardants for safe housing, both via the use of an assessment tool for safer flame retardants and via the introduction of alternative technologies.[74]

Sustainable Development Goal 12: Responsible Consumption and Production

Contributions to sustainable consumption and production in addition to Target 12.4 are also covered in a number of cases. For example, several best practices emphasise their contribution to Target 12.2 on the efficient use of natural resources, including via transformation of the feedstocks in chemical industry from fossil to regenerative raw materials and methane synthesis for fuelling cars with gas engines.[75] Other examples contribute to Target 12.6 by encouraging companies to adopt sustainable practices and integrating sustainability information into their reporting cycle.[76]

Sustainable Development Goal 13: Climate Action

Examples of best practices addressing Sustainable Development Goal 13 addressing climate change include the use of sustainable chemistry to improve industrial processes to reduce energy consumption and emissions of greenhouse gases.[77] Another example addresses the introduction of renewable feedstocks to replace fossil fuels as front-of-the-pipe intervention in integrated production systems.[78] The best practices also feature the use of sustainable chemistry for carbon capture, in the automotive sector, and in the production of polymers.[79]

3.4 Inputs on the Sustainably Chemistry Concept by Stakeholders

Several stakeholder responses provided complementary views regarding the sustainable chemistry concept. These tend and propose to frame the sustainable chemistry concept in a broad and holistic manner. A submission by an NGO, for example, notes that sustainable chemistry addresses environmental, social and economic aspects, thus covering the three dimensions of sustainable development underpinning the 2030 Agenda. The submission emphasises the need to maintain a focus on hazard reduction and notes that green chemistry would be a necessary, but not a sufficient component of sustainable chemistry. The submission also suggests the need to develop a definition of the concept.[80]

Along similar lines, a government submission puts forward a wide-ranging understanding of the sustainable chemistry concept. What qualifies as sustainable chemistry could be assessed based on a set of criteria that address all three dimensions of sustainable development (climate footprint, impacts on the environment, product design, risks to health, economic benefits, transparency, social standards,

[73] Best practice submission 'Dow HYPOL Binder For Improving Technology In A Sustainable Manner'
[74] Best practice submissions 'SAFR®: Integrating exposure with hazard in a new assessment approach for responsible flame retardant solutions'; and 'BLUEDGE™ Polymeric Flame Retardant Technology'.
[75] Best practice submissions 'Covestro – Dream Production'; and 'Audi-Power to Gas (PtG).
[76] For instance the best practice submissions 'Chemical Footprint Project'; and 'Green Chemistry and Commerce Council'
[77] See for example the best practice submissions 'CANVERA™ Polyolefin Dispersion for Can Coatings; Waste Heat Recovery'; and 'PERO & SAFECHEM – Cleaning of metal parts'
[78] Best practice submission 'Biomass Balance approach – A groundbreaking way of using renewable resources in production'
[79] Best practice submissions 'Audi – Power to Gas (PtG)' and 'Covestro – Dream Production'.
[80] Best practice submission 'Comments on Green Chemistry and Sustainable Chemistry in Response to Resolution 2/7 of the UN Environment Assembly'.

dialogue and international cooperation, etc.). These indicators are proposed primarily for the purpose of assessing products and processes.[81]

A submission by an industry association, referring to the outcomes of a multi-stakeholder workshop, reiterates the need to consider all three dimensions of sustainable development in exploring the contribution of chemistry to sustainable development. The submission also emphasises the continuing importance of a basic national regulatory infrastructure and availability of information.[82]

A submission by a scientific institution discusses the relationship between the concepts of green chemistry and sustainable chemistry, noting that while the terms are often used interchangeably, they may have different meanings in different countries and contexts. The institution notes that green chemistry and sustainable chemistry are not in contrast with each other and emphasises the need to focus on practical applications of both concepts.

4 UN Environment Survey on the Sustainable Chemistry Concept

4.1 Data Collection and Stakeholder Responses

In order to better understand stakeholder perceptions of the sustainable chemistry concept globally, UN Environment administered a survey in 2017 under the title: 'UN Environment Survey to Elicit Feedback on the Sustainable Chemistry Concept'. The purpose was to review perspectives, priorities, opportunities and challenges related to sustainable chemistry as seen by stakeholders from the public sector, the private sector and civil society, and to inform a dialogue what sustainable chemistry could mean in a global context.

UN Environment invited stakeholders of the Strategic Approach to International Chemicals Management, focal points of the Basel, Rotterdam and Stockholm Conventions, focal points of the Minamata Convention, as well as other internal and external partners to participate in the survey in May 2017. The initial deadline for submissions was set at 30 June 2017 and extended until 30 November 2017.[83]

The survey received a total of 63 responses. Respondents represented all UN regions (see Figure 2). It is worth noting that approximately two thirds of respondents were governments or other stakeholders from developing countries or countries with economies in transition. Responses were received from a variety of stakeholders As can be seen in Figure 3, most responses came from academia (ca. 35 %), followed by the public sector (ca. 24 %; 12 of the 15 responses came from developing countries and countries with economies in transition), the private sector (ca. 19 %), civil society (ca. 16 %), intergovernmental organizations (ca. 2 %) and others (ca. 5 %).

[81] Best practice submission 'Parameters of Sustainable Chemistry'.
[82] Best practice submission 'Convening Diverse Stakeholders on Chemistry in Sustainable Development'
[83] The online form used for the survey can be accessed via this weblink.

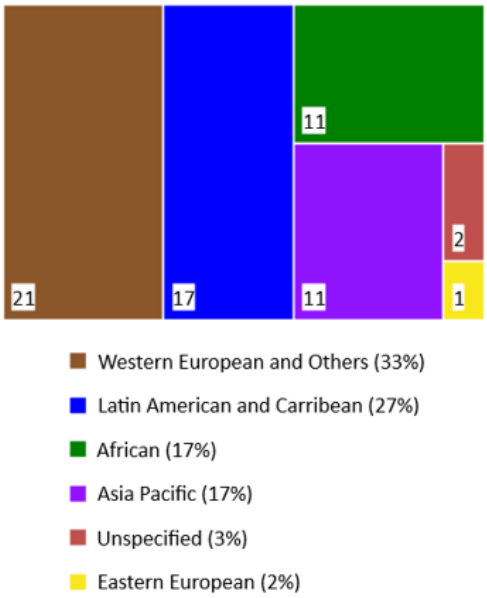

Figure 2 Responses by region from different stakeholders (n = 61, rounded percentages)

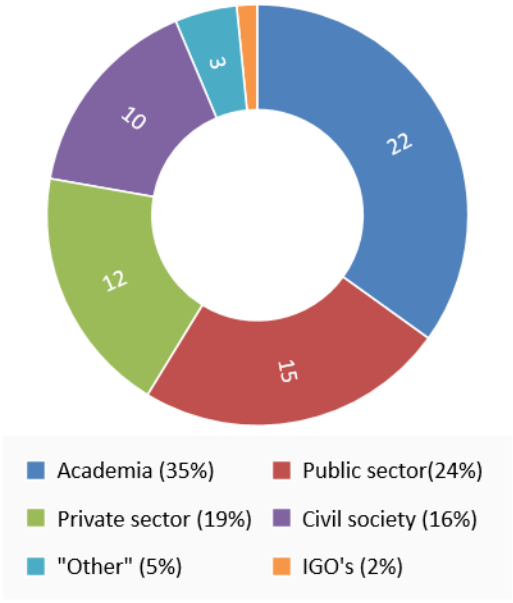

Figure 3: Responses by stakeholder groups (n = 61, rounded percentages)

4.2 Stakeholder Perspectives on the Sustainable Chemistry Concept

Perspectives on sustainable chemistry in an international context

A large majority (89 % agreement)[84] of respondents felt that sustainable chemistry is an important component relevant for in advancing chemicals and waste management beyond 2020. Asked more specifically concerning three possible perspectives on how the sustainable chemsitry concept could contribute in using the concept internationally, all three of the following proposed interpretations were supported (see Figure 4). The idea to use sustainable chemistry as an *assessment framework* for evaluating the contributions of chemicals to the Sustainable Development Goals received the strongest support (93 % agreement). The perspective that sustainable chemistry is a *new type of chemistry* which is compatible with the three dimensions of sustainable development also received very strong support (88 % agreement). The third option – sustainable chemistry as a *destiny and benchmark* – was seen less favourably, althought participants also supported it (74 % agreement).

[84] 61 respondents answered this question, i.e. 2 participants abstained

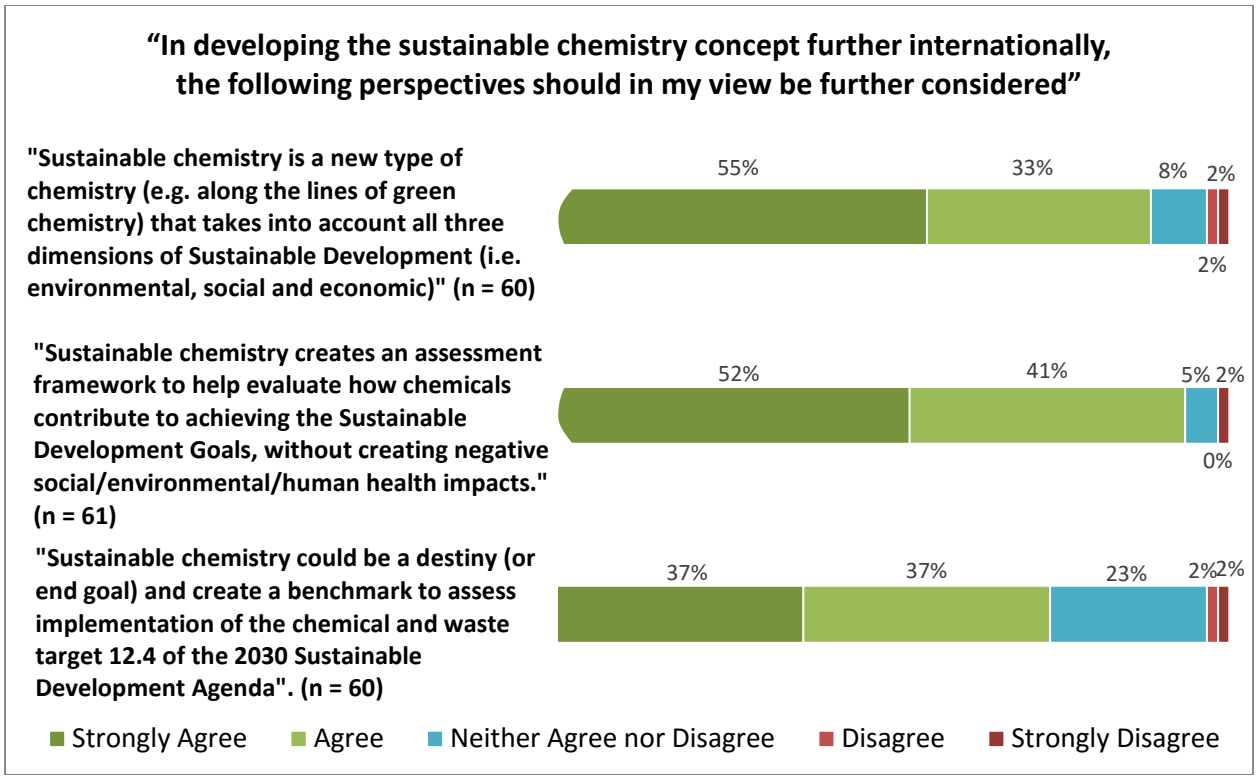

Figure 4: Sustainable chemistry in an international context (1) (rounded percentages)

The majority of respondends felt that an international definition of sustainable chemistry would be valuable (see Figure 5) and suggested an interest to develop the concept further internationally. Concerning a possible defition, results suggest a slightly higher preference for a detailed international definition compared to a simple one (72 % vs. 67 % agreement). In considering a simple definition, the large majority of participants (79 % agreement) supported a suggested option to frame it along the Brundlandt Commission's definition of sustainable development as follows: "Sustainable chemistry is the design, production, use, recycling and disposal of chemicals to support implementation of the 2030 Sustainable Development Agenda and meeting the needs of the present, without compromising the ability of future generations to meet their own needs".[85] A number of written comments provided by participants also support this finding, i.e. to keep the definition as simple as possible. Other written comments recommended to refrain from the attempt to define sustainable chemistry, with some suggesting to focus on addressing concrete areas and examples instead.

[85] This suggested option is in line with a reference to sustainable chemistry suggestion quote in the European Union publication on 'Novel materials and sustainable chemistry' (p. 4) (European Commission. (2008). Novel materials and sustainable chemistry – A decade of EU-funded research. ISBN 978-92-79-09721-8. Luxembourg: Office for Official Publications of the European Communities.

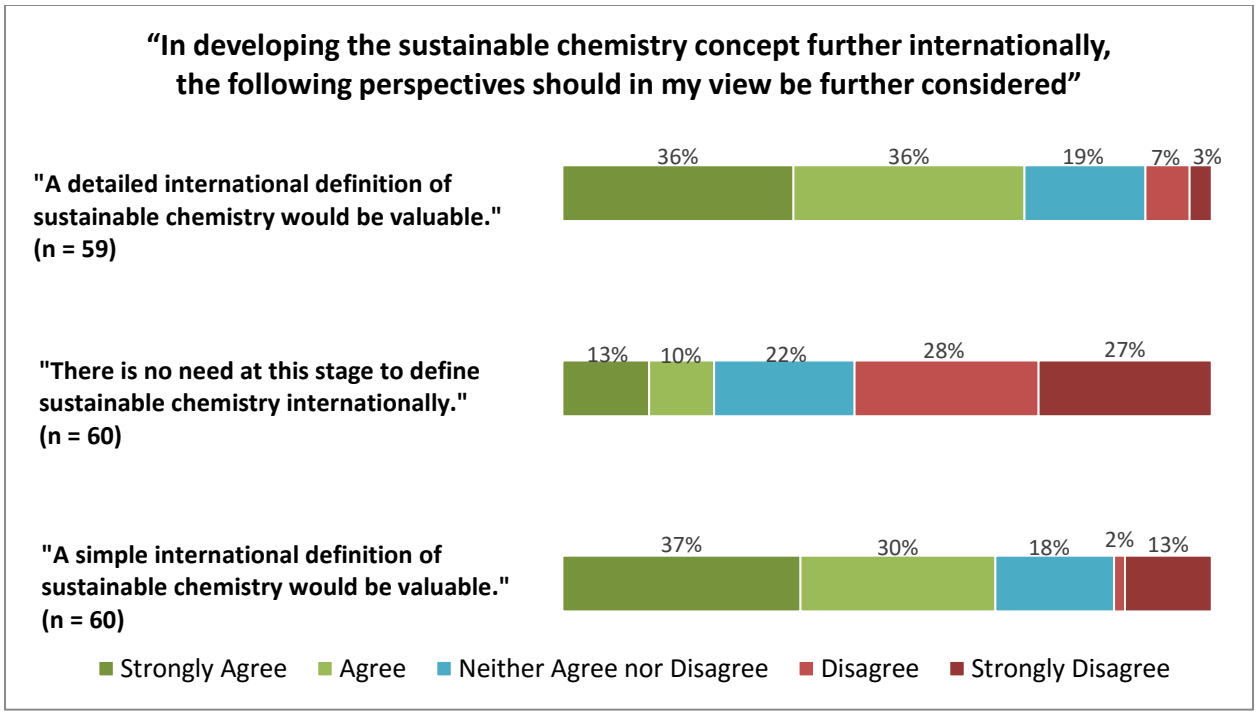

Figure 5: Sustainable chemistry in an international context (2) (rounded percentages)

Perspectives on topics covered by sustainable chemistry

The results of the survey indicate that a large majority of respondents strongly agreed or agreed that the sustainable chemistry concept encompasses the following:

- Identification and assessment of chemical and non-chemical alternatives for chemicals of concern (95 % agreement)
- Traditional chemical management tools, such as chemical hazard assessment, risk assessment and risk management (95 % agreement)
- Advancing technology transfer for safe chemicals and non-chemical alternatives (95 % agreement)
- Scaling up innovation through universities, start-up companies, and the chemical industry (91 % agreement)
- Reforming chemistry curricula to integrate green chemistry and sustainable development (90 % agreement)
- Use of economic instruments and innovative financing to advance innovation (82 % agreement)

Additional written comments confirm that participants favour a broad understanding of the sustainable chemistry concept. Through these comments, additional topics, such as the circular economy, life cycle assessment and resource efficiency, were also proposed. Several respondents also suggested that sustainable chemistry encompasses all stages of the life cycle and cuts across the entire value chain.

Perspectives on *Sustainable Chemistry in a Developing Country Context*

The survey results indicate that participants from developed countries as well as from developing countries and economies in transition see sustainable chemistry as holding a potential for developing countries, as shown in Figure 6: A large majority of respondents supported the statement that sustainable

chemistry creates an opportunity for leapfrogging chemicals management and technologies (81 % agreement in total; 90 % agreement among developed country respondents and 77 % agreement among respondents from developing countries and economies in transition). A large majority also supported the statement that technical assistance and technology transfer is important to advance sustainable chemistry in developing countries (88 % agreement). When distinguishing between responses from developed and developing countries, there was 95 % agreement among developed country respondents and 87 % agreement among respondents from developing countries and economies in transition.

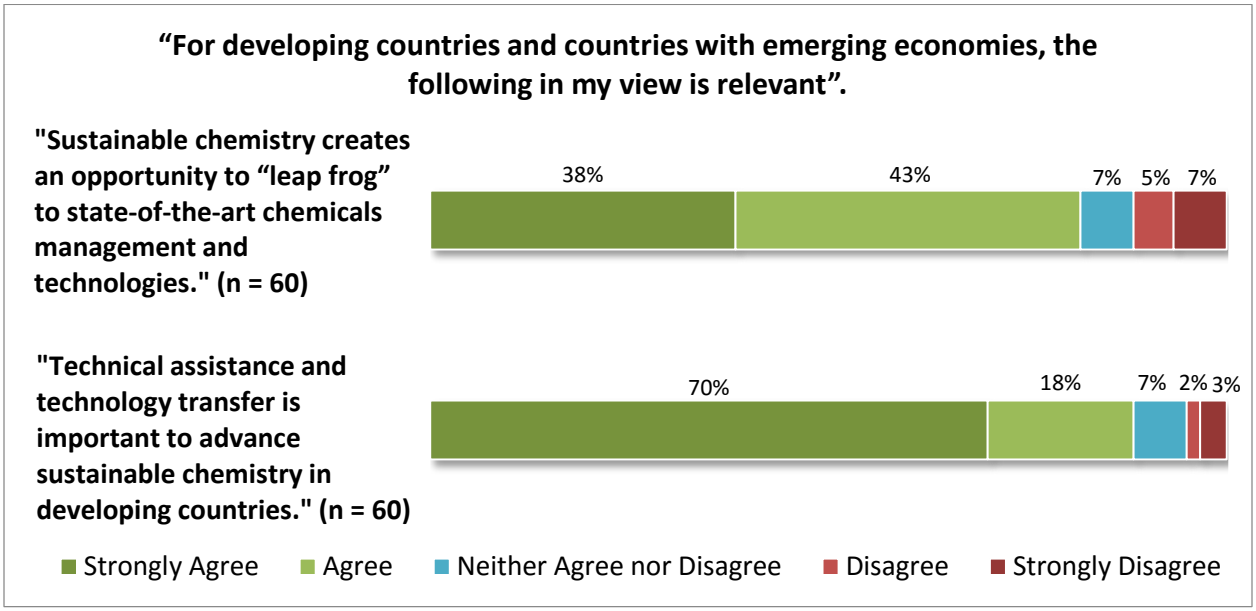

Figure 6:Sustainable chemistry in a developing country context (rounded percentages)

5 Summary Analysis

The preceding discussion suggests that sustainable chemistry is gaining momentum around the world and at the global level. However, the exact nature of sustainable chemistry, what it entails and how it can contribute needs further elaboration. In this context, the following considerations emerge from the analysis of best practices submitted in response to Resolution 2/7 adopted at the second session of the United Nations Environment Assembly and the UN Environment survey:

- Sustainable chemistry practices play a key role in achieving the Sustainable Development Goal Target 12.4 on the sound management of chemicals and wastes throughout their life cycle, including implementation of the Strategic Approach to International Chemicals Management and the chemicals and waste multilateral environmental agreements, and other related aspects of Sustainable Development Goal 12 on sustainable consumption and production
- At the same time, the concept also helps to examine, and focus in more detail on the contribution of chemistry in achieving the broader 2030 Agenda Sustainable Development Goals and Targets, such as zero hunger, climate action, safe housing, workers' health, innovation, and gender equality, while addressing all three dimensions of sustainable development.
- Given the interest of a large majority of stakeholders to further understand and develop the concept of sustainable chemistry internationally, a practical starting point could be to develop key elements, principles and characteristics of a sustainable chemistry assessment framework. Such

a framework could help to identify areas of action and innovation how chemistry can contribute to achieving the Sustainable Development Goals without creating negative social, environmental, and health impacts. It would also allow a more systematic identification of best practices of sustainable chemistry in the future.

- The development of an assessment framework could be complemented by further work on a simple definition of sustainable chemistry, or a more elaborate definition, if considered valuable.
- Advancing the concept sustainable chemistry as a new type of chemistry is also an option, but this could be challenging, given the existence of the established green chemistry approach which is well-defined. Green chemistry could, however, become an important component of a broader approach to sustainable chemistry.
- Similarly, the perspective that sustainable chemistry is further developed internationally to serve as a destiny or end goal is an option. However, given the already widespread use of the sustainable chemistry term to characterise initiatives and action, further careful reflection would be needed how the option of sustainable chemistry being a destiny could be integrated into ongoing international discussions to develop a vision for chemicals and waste management beyond 2020.

Annex A: Overview of Responding Entities Submitting Best Practices

#	Institution/organisation
	Public Sector
1	Agricultural Research Council, South Africa
2	Environment Ministry, Austria
3	Environment Protection Authority (EPA), Yemen
4	Federal Environment Agency, Germany
5	The Permanent Mission of Mexico, Mexico
6	The Supreme Council for Environment, Bahrain
	Intergovernmental organizations
7	The Organisation for Economic Co-operation and Development (OECD)
	Private sector
8	American Chemistry Council (ACC)
9	Amoéba SA
10	BASF SE
11	European Automobile Manufacturers' Association - ACEA
12	Foi Science (Pty) ltd
13	ICL Industrial Products Ltd
14	International Council of Chemical Associations (ICCA)
15	JACOR, LLC. EcoBioClean
16	MVO Nederland (CSR Netherlands)
17	Nordic Paper
18	Novartis
19	Pfizer Inc.
20	The Dow Chemical Company
	Civil society
21	Center for Public Health and Environmental Development (CEPHED), Nepal
22	Centre for Environment, Women, Education and Development (CEEWED), Nigeria
23	ChemSec, Sweden
24	International POPs Elimination Network (IPEN)
25	International Union of Pure and Applied Chemistry (IUPAC)
26	PAN Asia Pacific, Malaysia
27	PETA International Science Consortium
28	The Work Health and SurvivalProject, Greece
	Academia
29	Darmstadt University of Applied Sciences, Germany
30	Faculty of Technology and Metallurgy, Cleaner Production Centre of Serbia
31	Fundación Universidad de América, Colombia
32	Korea Research Institute of Chemical Technology, South Korea
33	Stockholm University, Sweden
34	The Water Academy, France

Annex B: List of Best Practices and Implementing Entities
(number in brackets corresponds to list in Annex A)

Public sector

5-point programme for sustainable plant protection (4)
Implemented by: German Environment Agency, International Chemicals Management, Germany
Summary: Provides principles for an integrated approach to sustainable plant protection.

Best practice code for the application of anticoagulant rodenticides (4)
Implemented by: The Federal Institute for Occupational Safety and Health (BAUA), Germany
Summary: A legally binding code regulating biocidal products containing anticoagulant rodenticides.

Biocides – Proposal for a concerted European approach towards a sustainable use (4)
Implemented by: German Environment Agency, International Chemicals Management, Germany
Summary: Proposes regulatory action to minimize the use and the effects of biocides.

Bioconversion of crude glycerol to ethylene (1)
Implemented by: Agricultural Research Council, Institute for Agricultural Engineering, South Africa
Summary: Introduction of a biological, renewable alternative to the thermochemical approach in ethylene production

Chemical leasing (2)
Implemented by: Environment Ministry, DG Waste, Chemicals Green Tec, Austria
Summary: Use of chemical leasing business model to reduce use of chemicals/improve efficiency.

The German Chemical Leasing Initiative (4)
Implemented by: German Environment Agency, International Chemicals Management, Germany
Summary: National chemical leasing project in multiple industry sectors to reduce the use of chemicals.

Chemicals Management in Bahrain (6)
Implemented by: Supreme Council for Environment, Chemicals management Unit, Bahrain
Summary: Establishment of a comprehensive regulatory system related to chemicals management.

Funding sound management of chemicals and hazardous wastes in Yemen (3)
Implemented by: Environment Protection Authority (EPA), General Department of Chemical Safety & Hazardous wastes, Yemen
Summary: Strengthening of human resources for the sound management of chemicals and hazardous wastes.

Indicator set "Parameters of Sustainable Chemistry" (PSC) (4)
Implemented by: German Environment Agency, International Chemicals Management, Germany
Summary: An indicator to assess specific sustainability measures applied in enterprises, mainly focused on processes and production.

International Sustainable Chemistry Collaborative Centre (ISC3) (4)
Implemented by: International Sustainable Chemistry Collaborative Centre (ISC3), Germany
Summary: Establishment of a centre to establish sustainable chemistry worldwide as a key component of sustainable development, addressing among others the dissemination of business models, support for developing countries in the safe management of chemicals, guidance on regulation etc.

Joint Office for Chemical Permissions (6)
Implemented by: Supreme Council for Environment, Chemicals management Unit, Bahrain
Summary: Establishment of a new office to join all related government authorities to permit and release chemicals rapidly.

Letter by the permanent mission of Mexico (5)
Implemented by: The permanent mission of Mexico, Mexico
Summary: A note indicating that no best practices have yet been identified.

National Action Plan on Sustainable Use of Plant Protection products (4)
Implemented by: The Federal Ministry of Food and Agriculture (BMEL), Germany
Summary: Qualitative regulations, targets, measures, indicators and timetables to reduce risks from the use of approved plant protection products.

Sub-select and guidance on sustainable chemicals (4)
Implemented by: German Environment Agency, International Chemicals Management, Germany
Summary: A tool to measure and compare the sustainability of substances and mixtures based on chemical properties.

Intergovernmental organizations

OECD Web Portal on PFASs (7)
Implemented by: The Organisation for Economic Co-operation and Development (OECD), EHS Division, France
Summary: Information exchange platform on per and poly-fluorinated chemicals (including risk reduction approaches) and their alternatives.

Substitution and Alternatives Assessment Toolbox (7)
Implemented by: The Organisation for Economic Co-operation and Development (OECD), EHS Division, France
Summary: A toolbox that provides resources for chemical substitution and alternatives assessments.

Private sector

A biological alternative to chemical in the treatment of cooling liquid microbial (9)
Implemented by: Amoéba SA
Summary: Use of a biological biocide to treat water in cooling towers of industrial or institutional sites.

Audi-PtG-Anlage (4)
Implemented by: Audi AG
Summary: Carbon capture and utilization via methane synthesis for further development of the Power to Gas technology for the operation of motor vehicles.

BASF – Argan program in Morocco (4)
Implemented by: BASF
Summary: Delivery of biologically produced Argan oil and its bio-products under fair-trade conditions by a cooperative network employing a large number of women from rural areas.

BASF-Trilon-M (4)
Implemented by: BASF
Summary: Phosphates in dishwashing tabs replaced by Trilon-M formulations.

Biomass Balance approach – A ground-breaking way of using renewable resources in production (10)
Implemented by: BASF SE, Sustainability Strategy
Summary: Sale of certified biomass balance products which rely on the use of renewable resources to replace fossil fuels in integrated production systems.

BLUEDGE™ Polymeric Flame Retardant Technology (20)
Implemented by: The Dow Chemical Company, Dow Coating Materials
Summary: A flame retardant technology with low toxicity relative to hexabromocyclododecane.

CANVERA™ Polyolefin Dispersion for Can Coatings (20)
Implemented by: The Dow Chemical Company, Dow Coating Materials
Summary: A water and energy efficient alternative to bisphenol A, styrene or formaldehyde in food and beverage metal packaging.

Capacity Building to Foster the Sound Management of Chemicals (14)
Implemented by: The International Council of Chemical Associations (ICCA
Summary: Voluntary industry initiative for capacity-building and product stewardship to implement environment, health and safety programs to manage chemical products throughout their lifecycle.

Chemistry for Green Building (8)
Implemented by: American Chemistry Council, Regulatory and Technical Affairs
Summary: Third-party auditing and supply chain guidance to certify the standards of buildings and building materials and products.

Covestro-Dream-Production (4)
Implemented by: Covestro
Summary: Carbon capture and utilisation via a catalyst that uses carbon dioxide instead of propylene oxide as a co-raw material in polyol synthesis.

Covestro-IMPACT-Technologie (4)
Implemented by: Covestro
Summary: Catalyst replacement of potassium hydroxide with double metal cyanide for higher quality and more sustainable polyether polyols

Dow HYPOL Binder for Improving Technology in A Sustainable Manner (20)
Implemented by: The Dow Chemical Company, Polyurethanes
Summary: Replacement of TDI technology with MDI technology in the development of a grow tile with binding properties allowing the provision of green spaces in places where it is usually not possible.

EcoBioClean Solves a Global Problem (15)
Implemented by: JACOR, LLC. EcoBioClean
Summary: Reverse-engineering of crude oil into bio-available components via a biocatalyst, reducing need for potentially toxic chemical reaction solvents.

Global Regulatory Monitoring System of chemical Substances (GRMS2) (11)
Implemented by: European Automobile Manufacturers' Association (ACEA) Environment
Summary: Monitoring and development of a database covering developments in chemicals legislation worldwide.

Green and sustainable technologies to develop a greener and more energy efficient process to manufacture Pregabalin, active ingredient in the drug Lyrica® (19)
Implemented by: Pfizer Inc., Chemical R&D/Worldwide R&D
Summary: Replacement of organic solvents with a biocatalyst for increased energy efficiency and higher output.

Green Chemistry and Commerce Council (24)
Implemented by: Green Chemistry and Commerce Council (GC3)
Summary: A business to business group working to accelerate implementation of green chemistry.

Kilian – Functional substitution (4)
Implemented by: Kilian Industrieschilder
Summary: A regenerative substitution of toxic solvents with fatty acid esters from coconut oils in the production of industrial labels.

Nanomaterials and Sustainability (4)
Implemented by: Öko-Institut
Summary: A tool to evaluate the sustainability of nanotechnology applications.

Natural Greaseproof (17)
Implemented by: Nordic Paper
Summary: Replacement of PFAS in treated paper using mechanical treatment of wood fibres.

Prometho GmbH – GrüneTinte (4)
Implemented by: Prometho
Summary: Replacement of finite and hazardous raw materials for the manufacture of black ink with renewable and non-hazardous feedstocks obtained from biomass.

Removing organic solvents from our processes (18)
Implemented by: Novartis, Chemical Development
Summary: Surfactant-mediated chemistry as a higher output, less costly, less organic solvent-reliant alternative in pharmaceuticals production.

SAFR®: Integrating exposure with hazard in a new assessment approach for responsible flame retardant solutions (13)
Implemented by: ICL Industrial Products Ltd, Product stewardship
Summary: A tool to help flame retardant users to choose a suitable product relative to the level of hazard and exposure.

Small scale fisheries waste recycling project (12)
Implemented by: Foi Sciennce (Pty) ltd, Research
Summary: Collection of waste from fish processing companies for use in wound and burn relief products, food additive etc.

Süd-Chemie: Waste Water Treatment (4)
Implemented by: Süd-Chemie AG
Summary: Commissioning of a plant capable of separating heavy metal nitrates from the wastewater.

Sustainable Solution Steering® - Contributing to sustainability needs (10)
Implemented by: BASF SE, Sustainability Strategy
Summary: Use of an assessment method to analyse the sustainability of the entire product portfolio

Sustainable Substitution Criteria (11)
Implemented by: European Automobile Manufacturers' Association (ACEA) Environment
Summary: Development of criteria for selecting safe non-regulated chemical alternatives to avoid regrettable substitutions.

Use of Green chemistry tools to influence route development for drug candidates (19)
Implemented by: Pfizer Inc., Chemical R&D/Worldwide R&D
Summary: Innovation and utilization of green chemistry tools such as solvent and reagent selection guides to improve the environmental performance in the synthesis of active pharmaceutical ingredients.

Waste Heat Recovery (4)
Implemented by: Deutsche Gasrußwerke (DGW)
Summary: Waste heat recovery, water recycling and the minimization of odour pollution in the furnace-black process.

Civil society

Banning of Import, Sale, Distribution and Uses of Asbestos in Nepal (21)
Implemented by: CEPHED, Environment and Public Health, Nepal
Summary: Awareness-raising campaign for a ban on the import, sale, distribution and use of asbestos.

Banning of Import, Purchase and Uses of all mercury based equipment's in health sector of Nepal (21)
Implemented by: CEPHED, Environment and Public Health, Nepal
Summary: Awareness-raising and capacity building efforts regarding the handling of mercury based equipment in the health sector.

Campaign for Standard of Children Toys (21)
Implemented by: CEPHED, Environment and Public Health, Nepal
Summary: Awareness-raising campaign for standards on chemicals of concern in children’s toys.

Chemical Footprint Project (24)
Implemented by: Chemical Footprint Project (CFP), United States
Summary: A performance assessment of a company's management of chemicals, identifying opportunities for improvement.

ChemSec Marketplace (23)
Implemented by: ChemSec, Sweden
Summary: A platform for substitution of hazardous chemicals, featuring advertisements of safer alternatives from producers, as well as requests for safer alternatives from downstream users.

Elimination of POPs and its Sources in Nepal (21)
Implemented by: CEPHED, Environment and Public Health, Nepal
Summary: Capacity-building and training on best practices to avoid waste burning at healthcare facilities as well as open burning.

Global Perspective on Success Stories and Best Practices in Chemical Safety Protecting Occupational and Environmental Health (28)
Implemented by: The Work Health and SurvivalProject, Sustainability and Law, Greece
Summary: Advocacy piece on the protection of occupational health and safety.

GreenScreen (24)
Implemented by: Clean Production Action, United States
Summary: A tool implemented by major corporations to identify hazardous chemicals and alternatives. The tool can guide procurement, product design, standards and policies.

Promoting PCB Free Metal Fabrication through Technology Transfer (21)
Implemented by: CEPHED, Environment and Public Health, Nepal Replacing Chemicals With Biology:
Summary: PCB containing/contaminated oil based welding machines replaced by dry welding machines, to protect grill workers and reduce contamination, including of dioxins and furans.

Phasing out Highly Hazardous Pesticides with Agroecology (26)
Implemented by: PAN Asia Pacific, Pesticides, Malaysia
Summary: Provision of assistance and practical guidance for policy- and decision-makers as well as farmers to replace highly hazardous pesticides with ecosystem-based approaches in order to reduce human health and environmental impacts, while also addressing food security, poverty and climate change.

Research based campaign for Mandatory Lead Paint Standard in Nepal (21)
Implemented by: CEPHED, Environment and Public Health, Nepal
Summary: Awareness-raising campaign on lead content in paint as well as lead contamination in buildings to advocate for the establishment of mandatory lead paint standards.

Sustainable Chemistry Policy Action Plan (22)
Implemented by: Centre for Environment, Women, Education and Development (Ceewed), Management, Nigeria
Summary: Development of a multi-stakeholder strategy for sustainable chemicals management.

Use of non-animal methods to develop safer chemicals (27)
Implemented by: PETA International Science Consortium, United States
Summary: Use of robust non-animal testing methods to assess toxicity in the development of safer chemicals and products.

Academia

Chemical Leasing (30)
Implemented by: Faculty of Technology and Metallurgy, Cleaner Production Centre of Serbia
Summary: Glue is invoiced to the user by number of glued boxes, not per kilogram.

Chemical Leasing in automotive parts industry (30)
Implemented by: Faculty of Technology and Metallurgy, Cleaner Production Centre of Serbia
Summary: Application of the chemical leasing business model in cleaning operations to reduce the use of hazardous chemicals, thus also protecting workers.

Chemical Leasing in Hotels (30)
Implemented by: Faculty of Technology and Metallurgy, Cleaner Production Centre of Serbia
Summary: The cleaning agents (for cutlery, laundry and rooms) are invoiced per kilogram of washed laundry or per occupied room instead per kilograms of chemicals.

For an IPCPE (international panel on the chemical pollution of the environment) to create an international expert body to periodically assess the state of the chemical pollution of the environment on the model of the IPCC or the IPBES (34)
Implemented by: The Water Academy, Board, France
Summary: Establishment of an international expert body to assess chemical pollution.

Identification of Sustainable Alternatives to Replace the Use of Asbestos in the Automotive Sector (31)
Implemented by: Fundación Universidad de América, Research, Colombia
Summary: Development of a documentary to raise awareness about the negative effects of asbestos, including exposure of workers, and to advocate for the phase out of its use in the automotive sector as well as other products.

IUPAC submission (25)
Implemented by: International Union of Pure and Applied Chemistry (IUPAC), Interdivisional Committee on Green Chemistry for Sustainable Development (ICGCDS), United States
Summary: Note on the interface between sustainable chemistry and green chemistry.

Safe and sustainable nanotechnology practices (33)
Implemented by: Stockholm University, Department of Computer and Systems Sciences, Sweden
Summary: Note on the nanotechnology sector, including a discussion of potential health and environmental issues from the use of nanotechnology.

Series of Postgraduate Summer Schools on Green Chemistry (25)
Implemented by: International Union of Pure and Applied Chemistry (IUPAC), Interdivisional Committee on Green Chemistry for Sustainable Development (ICGCDS), United States
Summary: The summer schools aim to teach students and researchers in chemistry how to apply principles of green chemistry to drive sustainable development.

Sustainable synthetic biology (33)
Implemented by: Stockholm University, Department of Computer and Systems Sciences, Sweden
Summary: Concept note advocating for the environmentally sound use of synthetic biology to avoid potential negative impacts while harnessing its potential.

Utilization of steel slag as a multi-purpose sorbent for pollutants (32)
Implemented by: Korea Research Institute of Chemical Technology, Center for Chemical Safety and Security, South Korea
Summary: Recycling of steel slag in environmental applications, such as acid-spill response, carbon dioxide sequestration, and sorbents for fluoride or heavy metals.

Wiki for chemical substance data to foster sound management of chemicals (29)
Implemented by: Darmstadt University of Applied Sciences, Society for Institutional Analysis (sofia), Germany
Summary: Adding of dashboards to the RWACH online registration dossiers featuring all available peer-reviewed studies on the respective substance.

Multi-stakeholder

3M – Recycling of PTFE (4)
Implemented by: 3M, Germany, the University of Bayreuth and the research institute InVerTec, Germany
Summary: Development of a pilot plant producing recycled high quality polytetrafluorethene from end of life material.

Convening Diverse Stakeholders on Chemistry in Sustainable Development (14)
Implemented by: The International Council of Chemical Associations (ICCA), UN Environment; and the China Petroleum and Chemical Industry Federation
Summary: A multi-stakeholder workshop exploring the role of chemistry in achieving sustainable development.

New interesting tool: The Sustainability Hotspot Scan (16)
Implemented by: MVO Nederland (CSR Netherlands), International CSR Program; the research institute Netherlands Organization for Applied Scientific Research (TNO), Netherlands; Baril Coatings B.V., C. Kornuyt BV; and the Dutch Institute for Health and Environment (RIVM), Netherlands
Summary: Development of a tool allowing chemical companies to assess the social and environmental impact of chemical products during their life cycle.

PERO & SAFECHEM – Cleaning of metal parts (4)
Implemented by: Safechem, Germany and Pero Innovative Services
Summary: Use of the chemical leasing business model to incentivise companies to consume fewer chemicals for the process of industrial parts cleaning for an automotive supplier.