PHOTO: BRIAN VAN DER BRUG/LOS ANGELES TIMES/GETTY IMAGES

ENVIRONMENTAL SCIENCE

We need a global science-policy body on chemicals and waste

Major gaps in current efforts limit policy responses

By **Zhanyun Wang[1], Rolf Altenburger[2,3], Thomas Backhaus[4], Adrian Covaci[5], Miriam L. Diamond[6,7], Joan O. Grimalt[8], Rainer Lohmann[9], Andreas Schäffer[3], Martin Scheringer[10,11], Henrik Selin[12], Anna Soehl[13], Noriyuki Suzuki[14]**

Many countries and regional political unions have regulatory and policy frameworks for managing chemicals and waste associated with human activities to minimize harms to human health and the environment. These frameworks are complemented and expanded by joint international action, particularly related to pollutants that undergo long-range transport via air, water, and biota; move across national borders through international trade of resources, products, and waste; or are present in many countries (*1*). Some progress has been made, but the Global Chemicals Outlook (GCO-II) from the United Nations Environment Programme (UNEP) (*1*) has called for "strengthen[ing] the science-policy interface and the use of science in monitoring progress, priority-setting, and policy-making throughout the life cycle of chemicals and waste." With the UN Environment Assembly (UNEA) soon meeting to discuss how to strengthen the science-policy interface on chemicals and waste (*2*), we analyze the landscape and outline recommendations for establishing an overarching body on chemicals and waste.

The world has seen a tremendous increase in the amount and variety of chemicals in use, with continuous growth expected; global chemical sales reached over US$5.6 trillion in 2017 and are projected to almost double by 2030 (*1*). Similar trends are also true for waste generation; for example, global plastic waste entering the ocean is estimated to increase from 4.8 to 12.7 million tonnes in 2010 to some 100 to 250 million tonnes by 2025 (*1*).

When chemicals and waste are poorly managed, not only are valuable resources lost, but chemical pollution can cause a wide range of adverse effects on human and ecosystem health at local, regional, and global levels. The latest Global Burden of Disease study estimated that exposure to lead and occupational exposure to 12 chemicals or groups of chemicals (a tiny fraction of the more than 100,000 chemicals in use) contributed to over 1.3 million premature human deaths in 2017 (*3*). Chemical pollution has also caused stratospheric ozone depletion, and it plays an important role in climate change (e.g., synthetic halogenated gases contributed over 10% of the global radiative forcing in 2011) (*4*) and ecosystem

Scientists conduct natural resource damage assessments in the aftermath of the oil spill in 2015 in Santa Barbara, California, informing policy-makers about planning and implementing restoration actions.

degradation (e.g., through the application of hazardous pesticides) (*1*).

For a large fraction of chemicals in use, substantial knowledge gaps hamper their sound management. Meanwhile, for those chemicals that are known as problematic or where there is emerging evidence of concern, control measures have often been limited (*1*). For example, although scientists have long raised concerns for widely used chemicals such as bisphenol A and some phthalates that they may act as endocrine-disrupting chemicals (and while informed action was taken in some countries and regions), they were identified by GCO-II in 2019 as issues with continued presence in many parts of the world, for potential joint action by the international community (*1*). Major gaps in the science-policy interface on chemicals and waste and how it keeps the international community up-to-date on scientific findings contribute to such delayed responses. This is particularly critical for developing countries, where national regulatory and policy frameworks are generally limited owing to a lack of capacity and accessibility of scientific information.

EXISTING SCIENCE-POLICY INTERACTIONS

The international community has a long history of taking concerted action on chemicals and waste. Much action happens through multilateral environmental agreements (MEAs) such as the Vienna Convention for the Protection of the Ozone Layer and its associated Montreal Protocol, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, and the Stockholm Convention on Persistent Organic Pollutants (POPs) (*5*). Other efforts are taken through individual or joint work programs by intergovernmental organizations such as UNEP, the World Health Organization (WHO), and the Food and Agriculture Organization (FAO) (*5*).

International chemicals and waste governance has greatly benefited from strong interactions between, and coproduction of, science and policy: Science informs policy developments, and policy incentivizes policy-relevant scientific research. An early example comes from the revelation by Svante Odén in the 1960s of links between sulfur dioxide emissions and acid rain in Europe. Odén's finding triggered a chain of science-policy interactions leading to the adoption of the Convention on Long-Range Transboundary Air Pollution (CLRTAP) (*6*). Science-policy coproduction has also been critical to the establishment of several other MEAs, including the Vienna Convention, the Montreal Protocol, and the Stockholm Convention, as well as the creation of the Arctic Monitoring and Assessment Programme (*5*).

To date, subsidiary science-policy interface bodies have been established under various MEAs and intergovernmental organizations to inform and support their work in specific areas related to chemicals and waste. For example, the POPs Review Committee was established under the Stockholm Convention for synthesizing scientific evidence of nominated chemicals and providing listing recommendations to the governing body of the convention [for more details on international chemicals and waste governance, the roles of science-policy interface bodies therein, and major current interface bodies, see the supplementary materials (SM)] (*5*, *7*). Although these bodies perform important roles in their respective areas, at least four critical gaps persist in the overall science-policy interface in international chemicals and waste governance (see fig. S1A and elaboration below; for more examples, see SM) (*7*, *8*). These gaps are highly problematic, particularly as scientific evidence regarding the environmental and human health concerns of chemicals and waste continues to grow.

FOUR MAJOR GAPS

First, there is a lack of coverage: The overall scope of existing interface bodies is limited and fragmented compared to the large and growing universe of chemicals and waste (*7*, *8*). Only a limited part of chemicals and waste is addressed by interface bodies under the global MEAs (e.g., POPs, mercury, ozone-depleting substances and replacements, and hazardous wastes). Interface bodies under global intergovernmental organizations may have wider scopes but are often constrained by the thematic domain of the host organization (e.g., environmental aspects under UNEP and human health aspects under WHO). Additional issues are addressed by regional and interregional interface bodies—e.g., atmospheric emissions of cadmium and lead under CLRTAP—yet these efforts remain inadequate in scope. Collectively, the lack of science-policy coverage of many issues related to chemicals and waste limits the international community's ability to identify and address issues of concern in a timely and informed way (*7*, *8*). In some cases, the lack of comprehensive scientific assessments has also provided space for intentional misrepresentation of scientific information due to conflicts of interest (*9*, *10*).

Second, there is a lack of horizon scanning and early warning mechanisms: Most existing interface bodies are not tasked, on a regular basis, with monitoring scientific developments and providing early warnings on risks related to chemicals and waste in their specific areas. Instead, many require external triggers to initiate work on specific issues. For example, the POPs Review Committee under the Stockholm Convention starts its assessments only after a party to the convention nominates a given chemical for potential control. Also, mechanisms for feeding informal early warnings by stakeholders into international governance processes are generally lacking. Consequently, the international community's ability to identify new issues for concerted action, even under existing MEAs, has been restricted. This is in sharp contrast to the rapid increase and diversification of chemicals and products in use and wastes, as well as the rapid generation of scientific findings, that demand constant vigilance and proactive assessment.

Third, there is a lack of bidirectional communication: Most interface bodies focus on informing policy-makers about scientific evidence on specific issues but take limited action to communicate policy developments and policy-relevant scientific questions back to the scientific community (*7*). Currently, policy needs for specific scientific evidence are often scattered over numerous documents under different MEAs and intergovernmental organizations, which are typically not read by, or accessible to, the scientific community, including funding agencies. This lack of policy-to-science communication restricts the scientific community from responding to policy needs with timely research.

Fourth, the wider scientific community is not sufficiently involved: Participation of scientists and practitioners (e.g., lawyers and physicians), particularly academics, in

[1]Institute of Environmental Engineering, ETH Zürich, 8093 Zurich, Switzerland. [2]Helmholtz Centre for Environmental Research UFZ, Permoserstrasse 15, Leipzig, Germany. [3]Institute for Environmental Research, RWTH Aachen University, Worringerweg 1, Aachen, Germany. [4]Department of Biological and Environmental Sciences, University of Gothenburg, Carl Skottsbergs Gata 22B, 40530, Gothenburg, Sweden. [5]Toxicological Centre, University of Antwerp, Universiteitsplein 1, 2610 Wilrijk, Belgium. [6]Department of Earth Sciences, University of Toronto, Toronto, Ontario, Canada. [7]School of the Environment, University of Toronto, Toronto, Ontario, Canada . [8]Department of Environmental Chemistry, IDAEA-CSIC, Barcelona, 08034, Spain. [9]Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, USA.[10]Institute of Biogeochemistry and Pollutant Dynamics, ETH Zürich, 8092 Zürich, Switzerland. [11]RECETOX, Masaryk University, 625 00 Brno, Czech Republic. [12]Frederick S. Pardee School of Global Studies, Boston University, Boston, MA, USA. [13]International Panel on Chemical Pollution, 8092 Zürich, Switzerland. [14]Center for Health and Environmental Risk Research, National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki, Japan. Email: zhanyun.wang@ifu.baug.ethz.ch

science-policy interactions on chemicals and waste remains limited and often occurs in silos. This is partly due to the limited scopes of existing interface bodies in terms of the chemicals they cover and the mandates they have, and a lack of opportunities for scientists and practitioners to participate in their work. This inadequate engagement and participation reduces the visibility and importance of science-policy work and international chemicals and waste governance in general. Thus, for academics, work at the science-policy interface on chemicals and waste is most often neither recognized nor rewarded, in comparison to using their time to write another academic article (*11*). This further reduces participation.

Existing interface bodies may be improved in relation to gaps 2 to 4. However, such an approach is not efficient, as a number of international negotiations would need to take place under different MEAs and intergovernmental organizations to enact these changes; nor is it effective, as existing interface bodies would still be bounded by their specific scopes and mandates.

A WAY FORWARD

Against the backdrop of these four gaps, we support the establishment of an overarching international body to facilitate and foster broad bidirectional science-policy interactions on chemicals and waste (fig. S1B). It needs to have an inclusive scope that can cover all chemicals and waste while avoiding duplicating efforts of existing interface bodies (gap 1). For policy-makers, it would produce robust and authoritative scientific assessments, synthesizing the scientific basis and analyzing options for action. The assessments can be initiated through preagreed work programs, e.g., regular horizon scanning and early warning of new and emerging issues (gap 2), and per request by MEAs and governing bodies of intergovernmental organizations. It would also inform the scientific community in a timely fashion about international policy developments and highlight policy-relevant scientific questions, e.g., by presenting at major scientific conferences and informing research funding organizations (gap 3). This could, in turn, help to increase participation by the scientific community in its work (gap 4).

Although the exact institutional design of this body must emerge from an international negotiation process, four core characteristics warrant consideration to ensure its scientific credibility, political legitimacy, and policy salience—critical factors for its effectiveness (*7*, *12*). First, setting it up as an intergovernmental body—e.g., under the joint auspices of intergovernmental organizations, including UNEP and WHO—will ensure salience of its work program and government ownership of its scientific assessments. This arrangement is necessary to foster uptake in international and national policy-making (e.g., under MEAs or governing bodies of intergovernmental organizations). Stakeholders such as civil society organizations and industry can participate as observers, providing their expertise and knowledge.

Second, having a clear definition of roles and responsibilities, a strict conflict-of-interest policy, and a rigorous peer-review process (for examples, see SM) will be critical to an objective, independent, and transparent work process and to the credibility and legitimacy of this body and its work. Third, ensuring wide involvement of scientists and practitioners, with balanced and diverse representation of relevant disciplines of natural and social sciences, gender, and regions, will help provide comprehensive, authoritative, and widely usable assessments. At the same time, the body needs to organize its work in an agile and flexible manner—e.g., by having separate working groups on distinct issues. Fourth, active communication of its findings with policy-makers, the wider scientific community (including funding agencies), stakeholders, and the public will help raise overall awareness of, and participation in, sound management of chemicals and waste.

Overarching science-policy interface bodies are no strangers to the international community. The Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) are two well-known and studied examples that provide holistic, balanced, and authoritative scientific assessments by thousands of scientists from different disciplines worldwide (*13*). The IPCC has played a critical role in informing international and national governance, and raising public awareness and urgency, about climate change. The IPBES is relatively new (established in 2012), but its impact on mainstreaming biodiversity and stimulating policy changes at various levels is evident (*14*). The wealth of knowledge and experience of IPCC, IPBES, and other interface bodies (see SM) offers important insights for designing an overarching science-policy interface body on chemicals and waste (although each thematic area and science-policy interface body has its own distinctive characteristics that need to be taken into consideration). For instance, the successful integration of natural scientific data, insights from social sciences, and local knowledge forms a strong basis for producing policy-relevant and usable information (*15*).

Not only can the overarching interface body on chemicals and waste learn from existing interface bodies, but it also may collaborate with them to conduct assessments that address multiple environmental and societal concerns in a synergistic manner. Setting up an overarching science-policy interface body on chemicals and waste will not solve all governance problems (e.g., a lack of effective national implementation and enforcement). However, it is a critical and necessary step toward strengthening informed policy-making for achieving the global sound management of chemicals and waste. ■

REFERENCES AND NOTES

1. United Nations Environment Programme, *Global Chemicals Outlook II - From Legacies to Innovative Solutions: Implementing the 2030 Agenda for Sustainable Development*; https://www.unenvironment.org/resources/report/global-chemicals-outlook-ii-legacies-innovative-solutions (2019).
2. United Nations Environment Programme, *Assessment of Options for Strengthening the Science-Policy Interface at the International Level for the Sound Management of Chemicals and Waste*, March 2020; https://wedocs.unep.org/bitstream/handle/20.500.11822/33808/OSSP.pdf?sequence=1&isAllowed=y (accessed 17 September 2020).
3. J. D. Stanaway *et al*., *Lancet* **392**, 1923 (2018).
4. G. Myhre *et al*., "Anthropogenic and Natural Radiative Forcing" in *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, T. F. Stocker *et al.*, Eds. (Cambridge Univ. Press, 2013); www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf.
5. P. Wexler, J. van der Kolk, A. Mohapatra, R. Agarwal, Eds., *Chemicals, Environment, Health: A Global Management Perspective* (CRC Press, 2012), pp. 1–810.
6. P. Grennfelt *et al*., *Ambio* **49**, 849 (2020).
7. Z. Wang, I. Summerson, A. Lai, J. M. Boucher, M. Scheringer, *Strengthening the Science-Policy Interface in International Chemicals Governance: A Mapping and Gap Analysis*, Zenodo (2019); https://zenodo.org/record/2559189#.X3Tany1h3ao
8. M. Scheringer *et al*., *Environ. Sci. Pollut. Res. Int*. **13**, 432 (2006).
9. F. Lawrence, *Nature* **578**, 28 (2020).
10. M. Karlsson, *Sustainability* **11**, 4785 (2019).
11. G. G. Singh *et al*., *Front. Ecol. Environ*. **17**, 375 (2019).
12. D. W. Cash *et al*., *Proc. Natl. Acad. Sci. U.S.A*. **100**, 8086 (2003).
13. S. Beck, T. Forsyth, P. M. Kohler, M. Lahsen, M. Mahony, "The Making of Global Environmental Science and Politics" in *The Handbook of Science and Technology Studies*, C. Miller, L. Smith-Doerr, U. Felt, R. Fouché, Eds. (MIT Press, ed. 4, 2016).
14. M. H. Ruckelshaus *et al*., *Trends Ecol. Evol*. **35**, 407 (2020).
15. E. Löfmarck, R. Lidskog, *Environ. Sci. Policy* **69**, 22 (2017).

ACKNOWLEDGMENTS

The authors gratefully acknowledge G. White (Health Canada), M. Tschirren (Swiss Federal Office for the Environment), S. Sakai (Kyoto University), and S. T. Jahre (Norwegian Ministry of Climate and Environment) for helpful comments. The authors declare no competing interests. M.S. acknowledges financial support by the CETOCOEN PLUS project (CZ.02.1.01/0.0/0.0/15_003/0000469) of the Ministry of Education, Youth and Sports of the Czech Republic.

SUPPLEMENTARY MATERIALS

science.sciencemag.org/content/371/6531/774/suppl/DC1

10.1126/science.abe9090

Science

We need a global science-policy body on chemicals and waste

Zhanyun Wang, Rolf Altenburger, Thomas Backhaus, Adrian Covaci, Miriam L. Diamond, Joan O. Grimalt, Rainer Lohmann, Andreas Schäffer, Martin Scheringer, Henrik Selin, Anna Soehl and Noriyuki Suzuki

Science **371** (6531), 774-776.
DOI: 10.1126/science.abe9090

Science (print ISSN 0036-8075; online ISSN 1095-9203) is published by the American Association for the Advancement of Science, 1200 New York Avenue NW, Washington, DC 20005. The title *Science* is a registered trademark of AAAS.