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Feature

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ABSTRACT: Pollution by chemicals and waste impacts human and ecosystem health on regional, national, and global scales, resulting, together with climate change and biodiversity loss, in a triple planetary crisis. Consequently, in 2022, countries agreed to establish an intergovernmental science−policy panel (SPP) on chemicals, waste, and pollution prevention, complementary to the existing intergovernmental science−policy bodies on climate change and biodiversity. To ensure the SPP's success, it is imperative to protect it from conflicts of interest (COI). Here, we (i) define and review the implications of COI, and its relevance for the management of chemicals, waste, and pollution; (ii) summarize established tactics to manufacture doubt in favor of vested interests, i.e., to counter scientific evidence and/or to promote misleading narratives favorable to financial interests; and (iii) illustrate these with selected examples. This analysis leads to a review of arguments for and against chemical industry representation in the SPP's work. We further (iv) rebut an assertion voiced by some that the chemical industry should be directly involved in the panel's work because it possesses data on chemicals essential for the panel's activities. Finally, (v) we present steps that should be taken to prevent the detrimental impacts of COI in the work of the SPP. In particular, we propose to include an independent auditor's role in the SPP to ensure that participation and processes follow clear COI rules. Among others, the auditor should evaluate the content of the assessments produced to ensure unbiased representation of information that underpins the SPP's activities.

KEYWORDS: *human health, ecosystem health, science−policy panel, conflict of interest*

1. INTRODUCTION

Worldwide, more than 350 000 chemicals have been registered for production and use.[1] With continuously increasing production, multifaceted adverse impacts, and a lack of public oversight throughout their life cycle(s), an argument has been made that chemicals as a whole have transgressed the planetary boundary, including specific examples such as per- and polyfluoroalkyl substances (PFASs). Further, the annual production and releases of chemicals and chemical products are increasing faster than the global capacity for assessment and monitoring.[2−5]

Most chemicals used in society, such as various pharmaceuticals and personal care products, pesticides, and industrial chemicals, are used and distributed globally. As a result, these

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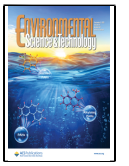

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contaminants are found everywhere, even in locations remote from their production and use, including polar environments, mountain ranges, and the deep sea.[6−9] Many of these chemicals remain in the environment even long after discontinuation of their production because of prolonged use and storage in the technosphere and environmental reservoirs where they are resistant to degradation processes. In addition, many parent compounds used in industrial processes and consumer products form new chemicals (transformation products) when interacting with the natural environment, further adding to the complexity of chemical exposures; others are formed unintentionally from processes such as incineration.

While delivering benefits through their intended function, many anthropogenic chemicals, including the anthropogenic use of metals, are linked to a wide range of severe adverse impacts on human health and ecosystems. They also cause other major problems such as ozone depletion, global warming, and antibiotic resistance. Further, pollution by increasing amounts of waste leads to growing contamination of air, soil, water, and wildlife worldwide.[10] All of these adverse effects are associated with enormous efforts and costs for treatment and remediation, if this is at all possible.[11−15]

Concerns about these and other risks have been raised,[16] leading to the decision by countries around the world at the United Nations Environment Assembly (UNEA) in 2022 to establish an intergovernmental science−policy panel on chemicals, waste, and pollution prevention (SPP).[17] Aiming to support countries and other societal actors in their efforts to protect human and ecosystem health through scientific assessments, the SPP will complement two other important intergovernmental science−policy bodies, the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

To ensure its effectiveness, it is crucial to establish operative mechanisms for the setup and work of the SPP and to protect the SPP from undue influence by parties with vested interests, i.e., conflicts of interest (COI). The role of certain industries is of concern, in particular because entrenched companies have a vested interest in protecting revenue-generating chemicals, often despite mounting evidence that these substances cause detrimental impacts on public health and/or the environment (see examples in section 4). Furthermore, these industries often promote the need for ever-expanding chemical production and consumption as an indispensable contribution to economic growth.[18] Notably, economic growth is a linchpin in most policies and regulations aiming for human and ecosystem protection, such as the EU's Chemicals Strategy for Sustainability (CSS)[19] and activities conducted under the Global Environmental Facility (GEF).[20] Thus, tension exists between those who strive for provisions to protect human and ecosystem health and those whose direct economic interests could be negatively affected by the outcome of those provisions.

It should be noted that many companies strive to provide safer alternatives by systematically replacing chemicals of concern with less problematic substitutes, practicing sustainable production conditions, switching business models to use fewer chemicals and smaller amounts of chemicals, and preventing waste generation. However, such practices are not embraced consistently throughout industries across the globe.

This article is motivated by the discussions on the ongoing negotiations about the future SPP's institutional design and governance, including the chemical industry's role in the forthcoming SPP. In this context, we (i) define and review the implications of COI and its relevance for chemicals management and policy development; (ii) summarize known tactics to manufacture doubt in favor of vested interests, i.e., to counter scientific evidence and/or to promote misleading narratives favorable to financial interests, and (iii) illustrate this with selected examples; and (iv) rebut an assertion voiced by certain parties that the chemical industry should be directly involved in the panel's work, because it possesses data on chemicals essential for the panel's activities. This analysis leads to a review of arguments for and against chemical industry representation in the SPP's work. Finally, (v) we discuss guard rails and present steps that we believe should be taken to prevent the detrimental impacts of COI in the SPP.

2. CONFLICT OF INTEREST (COI)

Numerous organizations have defined and implemented guidelines for managing conflicts of interest.[21] The IPCC's definition of COI is as follows:

> *Conflict of interest refers to any current professional, financial or other interest which could: i) significantly impair the individual's objectivity in carrying out his or her duties and responsibilities for the IPCC, or ii) create an unfair advantage for any person or organization. ... Circumstances that could lead a reasonable person to question an individual's objectivity, or whether an unfair advantage has been created, constitute a potential conflict of interest. These potential conflicts are subject to disclosure.*[22]

The IPCC policy states that bias is not *per se* a conflict of interest. It is unavoidable that every expert holds a particular point of view or perspective that could be seen as biased. Rather, a conflict of interest arises when that individual could have a "direct and material gain" in a certain outcome of an activity, consultation, etc. Conflicts of interest can arise also for nonfinancial reasons such as institutional affiliations, political worldviews, or personal relationships (friendships or enmities). Herein, we focus on aspects of direct and indirect economic gain.

Conflicts of interest should not be confused with interests,[23] which are a commitment, goal, obligation, or duty associated with a particular social or scientific role or practice. Conflation of conflicts of interest with interests [including research/professional interests and holding a position in or advising a nongovernmental organization (NGO)] in general serves to muddy the waters about how to manage conflicts of interest, generating confusion about the nature and definition of the problem and doubt about whether conflicts of interest can be addressed at all.[24]

Managing conflicts of interest is important so that the functions of regulatory and scientific bodies are not impaired. For example, unchecked participation with equal footing in a process or activity of an actor with a conflict of interest that is in opposition to the goal of that process or activity is likely to result in conflicting and/or incompatible outcomes or delayed implementation of solutions.[25] Such delays are costly[26] (see sections below). In addition, conflicts of interest can erode trust in science, first by intentionally damaging the public's attitude toward scientists and their research[27] and by weakening the trusting interdependence among scientists.

Here, we focus on conflicts of interest that could be held by for-profit entities, such as the chemical industry, associated industry groups and trade associations (even if registered as not-for-profit organizations), and consultancies working for

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them. As discussed below, such organizations have repeatedly sought to influence regulatory decision making and policy development, particularly by manufacturing doubt about clear evidence documenting harm associated with specific actions or products, to protect their own financial interests or the financial interests of their clients.

For an evaluation of the IPCC's COI policy, we refer to the work of Chan et al.,[28] who looked in detail at potential weaknesses in these policies. The IPCC is explicit on the distinction between conflict of interest and bias: "Holding a view that one believes to be correct, but that one does not stand to gain from personally is not a conflict of interest" (statement 12).[22] This statement does not clearly state whether a benefit to the individual's employer would be seen as personal benefits. Clarification of these ambiguities should be made as the new SPP designs its COI policy.

Authors of IPCC reports with clear conflicts of interest are allowed to continue participating under "exceptional circumstances ... where the individual is deemed to provide a unique contribution to an IPCC product and where it is determined that the conflict can be managed such that it will not have an adverse impact on the relevant IPCC report". For example, the IPCC has included authors from industry in their reports, which has been criticized because this constitutes a COI.[28] Such involvement of individuals with COI should not occur in the new SPP; they should be allowed to only observe the process but not become authors of reports created by the panel.

3. TACTICS FOR MANUFACTURING DOUBT

In his 2008 book *Doubt is Their Product*,[29] David Michaels quoted a cigarette executive who once observed: "Doubt is our product, since it is the best means of competing with the body of fact that exists in the minds of the general public. It is also the means of establishing a controversy." Multiple examples of vested interest engagement in manufacturing doubt around contemporary issues, ranging from tobacco to climate change, have also been reviewed by Oreskes and Conway in their 2010 book *Merchants of Doubt*.[30] More recently, Goldberg and Vandenberg summarized more than two dozen strategies and tactics that have been used by multiple organizations either to counter scientific evidence or to promote narratives favorable to the specific industry sectors.[27,31] The most common tactics extracted from their detailed investigation include the following:

1. To criticize study design to highlight shortcomings, such as issues of statistical confounding or the sample size, and then to overemphasize the impact on the results.
2. To discredit the authors of a study or other opponents in general, in the scientific media, web pages, or the general press, which is sometimes done with the support of respected individuals from government, industry, journals, academia, or health organizations. A related tactic is intimidating authors through official requests for information, including personal emails (e.g., requests through freedom-of-information provisions), threats of potential lawsuits, and/or allegations of wrongdoing.[32−35]
3. To publish misinformation using consulting companies that specialize in supporting private interests, often without disclosing the conflict of interest associated with their contractual obligations that can significantly impair the output's objectivity.
4. To hide the sources of funding for research, ensuring that such resources cannot be easily traced back to their source.
5. To misrepresent information by selectively cherry-picking data, designing studies to fail or come to a desired conclusion, or conducting meta-analyses that dilute scientific evidence.
6. To use exaggerated and misrepresentative language to separate sound or good science from poor science, e.g., by industries claiming to be constrained by chemical regulations that have been based on "bad or junk science".[36]
7. To influence government agencies and legislation by gaining undue proximity to regulators and policy makers. This is achieved by investing more resources for lobbying than is possible for other organizations, so that the voice of the vested interest is often the main or even the only one heard in public consultations.[37]
8. To generate and provide misleading literature,[38−40] organize/fund conferences, exploit scientific illiteracy, and alter products to make them appear healthier.

An important component of this overall strategy is to instill a common requirement to seek an (opposing) second opinion on a subject, via a strategy often termed false balance or false equivalency. This strategy is promoted as a means to avoid bias and give a balanced view on the subject. Rather, this strategy typically serves to give the appearance of an ongoing scientific debate when, in fact, scientific consensus has been reached on the matter and the second opinion is an outlier in those scientific discussions.[37,41,42]

These tactics are further elaborated below, where we provide detailed examples from different industries and for different classes of chemicals.

4. CONFLICT-OF-INTEREST-INDUCED BIAS AND MANUFACTURING OF DOUBT ABOUT SCIENTIFIC EVIDENCE

Tobacco Industry. Health scientists know today that both smoking and passive smoking (secondhand smoke exposure) increase the risk of serious diseases such as lung cancer, respiratory diseases, and heart diseases. Still, Barnes et al.[43] found that approximately one-third of 100 articles on the impact of passive smoking concluded that passive smoking is not harmful. This apparent contradiction dissolves when one takes a closer look at the authorship of the articles: 74% of the authors were affiliated with the tobacco industry.

For decades, the tobacco industry systematically generated controversy about the health risks of its products.[44] Miller et al. categorized the tobacco industry's manipulation tactics for direct action, such as political and media campaigns and spending on initiatives to counter tobacco control regulations.[45] Those tactics include the systematic distortion of scientific evidence, for example, by funding scientific reports that disputed the evidence of harm. Another frequently employed tactic is the deflection of concerns by applying corporate "social- and/or pink-washing efforts" that target vulnerable groups.[43−45] These terms refer to disingenuously claiming concern for a social issue or group, notably LGBTQ+ rights and breast cancer, but then acting contrary to that concern. An additional tactic is conducting systematic disinformation campaigns, for instance, with regard to indoor smoking policies. For e-cigarettes, articles of authors with a COI due to their links

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to pharmaceutical, tobacco, and e-cigarette companies are more likely to contain conclusions favorable to this modern type of smoking.[46,47]

Soft-Drink Industry. Soft-drink consumption has been related to excess energy consumption; the displacement of other foods and beverages and, therefore, nutrient intake; adverse effects such as obesity and diabetes; and the commercial exploitation of children. These concerns have been countered by industry associations with several arguments such as the science linking soft-drink consumption to adverse health outcomes is flawed or insufficient. In addition, the sale of soft drinks in schools was raised as beneficial by the soft-drink industry, where some of the income from sales helps education by providing needed funds for those schools; and arguments that physical activity is more important than food intake.[48] Reviews of soft-drink research that reported COI with food or beverage companies were 5 times more likely to conclude that there was no link between soft-drink consumption and weight gain or obesity than those that reported no industry sponsorship or COI. This lack of consistency between the publications from authors with and without COI suggests empirical evidence of COI-related bias.[49] In another recent example, the International Food Information Council (IFIC), a major participant in policy making processes on food and beverages, was revealed to be connected with large food and beverage companies and found to "employ ... self-designed research and media outreach to disseminate nutrition information ... to pre-emptively counter information about the negative health impacts of added sugars and ultra-processed foods, and promote ... a personal-responsibility narrative about dietary intake and health".[50]

Nuclear Power Industry. The world is in the midst of a dramatic climate crisis, caused by the use of fossil fuels. In the face of imminent climate change that is altering the conditions of the entire planet, most jurisdictions are striving for economically efficient low-carbon solutions. While there may be climate-related reasons for using carbon-free nuclear power (notwithstanding the unavoidable problems of generating nuclear fuels, ensuring operational safety, and the disposal and safe storage of radioactive waste), flawed nuclear cost analyses, perpetuated by the nuclear industry, jeopardize the use of cheaper and cleaner technologies, such as wind and solar energy.[51] Plans for new nuclear energy generation based on unrealistically low costs could therefore reduce the market's desire to invest in renewable technologies.

Fossil Fuel Industry. Furthermore, energy companies and their investors continue to expand exploration and production of fossil fuels for energy and as a feedstock for chemical production while achieving record profits, ignoring the warnings of climate scientists and public health experts.[52,53] Cases of funder bias have also been reported. For example, industry-funded energy science centers at universities were found to produce communications favoring natural gas over renewable energy, while centers less dependent on industry funding showed the opposite pattern.[54]

Pharmaceutical and Healthcare Industry. The history of modern drug development and regulation has been replete with egregious examples of COI, which in some cases resulted in significant impacts on public health.[55,56] Numerous studies have demonstrated that industry-sponsored studies are likely to generate conclusions that favor industry.[57−59] Such conclusions are reached, for example, by designing experiments in such a way as to attain desirable outcomes but also may be due to, in part, publication bias, i.e., a prioritized publication of studies with positive or significant results, or deliberate omission to publish studies with negative outcomes. Notably, evidence of publication bias has also been reported for non-industry-funded researchers.[60]

Pesticide Industry. Pesticides increase agricultural yields but also cause environmental contamination and, as a consequence, biodiversity loss. For example, atrazine is widely used as a herbicide to control broadleaf and weedy grasses in crops such as corn and sugar cane. Bero et al.[61] found that of 39 studies, 50% of industry-sponsored studies concluded that atrazine was not harmful to animals through reproductive or developmental effects, compared to 18% of non-industry-sponsored studies.

COI might be particularly problematic in countries with a regulatory system that is still developing. For example, Rocha and Grisolia[62] showed that hazardous pesticides (some of which are restricted in the European Union) are authorized in Brazil. Importantly, the toxicological data considered by the Brazilian regulatory authorities came exclusively from studies that were submitted by pesticide companies and/or were carried out by private contract laboratories. The authors found that none of the studies regarding mutagenicity, carcinogenicity, and reproductive toxicity conducted by private contract laboratories (used for the registration of 247 pesticide formulations in Brazil) revealed any toxic effects. However, of the 574 studies found in the scientific literature on the toxicological properties of these same pesticides, 84% of the studies carried out by researchers from public institutions found toxic effects.

Another example is the widely used herbicide Roundup, which contains the active ingredient glyphosate along with formulation chemicals that may increase the toxicity of the product.[63−65] Close ties between regulatory agencies and the pesticide industry have been reported, including revolving doors, reliance on unpublished industry papers while dismissing papers published by independent scientists, and covert industry influence on the regulatory process.[66] Also, despite a clear legal requirement to disclose all performed studies, the pesticide industry withheld a substantial number [9 of 35 (26%)] of developmental neurotoxicity studies from EU authorities. If these studies had been submitted to the evaluating competent authorities, seven of the studies could have altered the outcome of the assessments.[67,68]

The reaction to bias in the evaluation of pesticides is in some cases inadequate and makes the problem worse. In Paraguay, for example, the national body that decides on research funding changed the composition of the panel to include pesticide industry scientists with COI after academic scientists published papers on genetic damage in children exposed to pesticides.[69]

Plastics Industry. Ample evidence demonstrates the negative environmental and human health impacts of plastics and plastics-associated chemicals.[70−74] A historical example of efforts to thwart action to reduce plastic pollution through political approaches dates back to the 1960s with the Keep America Beautiful campaign and a series of ad campaigns, including the Crying Indian commercial, which promoted the idea that plastic waste pollution is the fault of consumers rather than the problematic properties of the products themselves.[75]

There is currently widespread public and political support to restrict plastics production and to better regulate the market.[76] However, petrochemical industries and plastic producers were present in force at the first Intergovernmental Negotiating Committee (INC) meeting for the Plastic Treaty negotiations,

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pushing misleading statements (e.g., that the problem can be solved with improved waste management or that an increase in plastics production helps to reach climate goals)[77] while principally ignoring human and environmental health impacts beginning with the extraction of fossil fuels and then the plastic production itself. Their participation was countered with calls from non-industry participants to restrict industry's influence due to their COI,[78] referring to WHO restrictions on the participation of the tobacco industry in discussions around smoking.[79]

Big Oil, an association of several large oil and gas companies, has engaged in activities to delay action to cap plastics production and hinder transparent reporting about the chemical composition of plastic products.[80] This was done via lobbying[81] and campaigning efforts directed toward blocking legislation and focusing blame for plastic pollution on individual consumers and plastics mismanagement.[82] The lack of transparency around chemicals in plastics hinders work toward achieving a circular economy as producers do not reveal the chemical composition of their products.[83]

Flame Retardants. For decades, some chemical manufacturers[84] and contract laboratories[85] have been involved in deceptive and fear mongering campaigns in support of voluntary industry and regulatory flammability standards that require certain products to meet flammability tests (e.g., upholstered furniture, building insulation, electronic enclosures, and vehicle interiors). For-profit test laboratories directly benefit from such standards as products have to undergo specialized flammability tests that only they can conduct. Chemical companies benefit from the inclusion of specific flammability tests in these standards and regulations because the most affordable way to meet these standards is often with the use of chemical flame retardants that they produce. Examples of such chemicals include brominated and chlorinated organic compounds and organophosphate esters. Conversely, the data to support the contention that meeting these flammability standards actually reduces risks from structural fires are scant, and thus, some widely adopted flammability standards have been found not to provide meaningful fire safety benefits.[86,87]

The use of flame retardants has been linked to population level adverse effects.[88] An investigative article by the *Chicago Tribune* documented some of the tactics used by chemical manufacturers and their front groups, calling into question the widespread use of flame retardants in household furniture because flame retardants in the foam were ineffective at providing any significant protection.[89] Public awareness raised by this investigative reporting enabled the revision of California flammability standards (TB-117 and TB-133).[88] Despite this change, other flammability standards remain and others are being advocated on the basis of a fire safety argument, which needs to be met by shifting from one phased-out flame retardant to poorly studied alternatives, often termed a cycle of regrettable substitution.[90]

Per- and Polyfluoroalkyl Substances (PFASs). Toxicological findings, including cancer, related to exposure to perfluorooctanoic acid (PFOA)[91] were challenged by industry-hired experts with COI and subsequent lobbying of the U.S. National Toxicology Program to downgrade the hazard classification of PFOA.[92,93] The same company agreed much later to cease production of PFOA, apparently because of the overwhelming evidence of such causal links.[94] Statements about the environmental safety of fluorinated polymers ignore impacts over the life cycle of fluoropolymers, i.e., during production (made famous in the movie *Dark Waters*) and at the end of life.[95−101]

Endocrine-Disrupting Chemicals. Concerted lobbying efforts by American and European chemical industries led to delays in the European Commission efforts to implement regulations for endocrine-disrupting chemicals (EDCs).[102] Tactics such as overstating minor methodological flaws in studies and/or ignoring evidence of harmful effects were used in the chemical industry's harsh criticism of the descriptions of the objectives, findings, and conclusions of the UNEP-WHO report on EDCs.[102,103] Building on attempts to mislead nonspecialists and decision makers by confusing the science in the case of the European Commission, chemical industry members questioned its methodology and conclusions when the report was introduced for global consideration at the fourth session of the International Conference on Chemicals Management (ICCM4). When all other interested parties welcomed this report, the International Council of Chemical Associations, CropLife International, and the U.S. Council for International Business insisted on and were able to add a footnote to the ICCM4 meeting report noting that the methodology and conclusions of the report remain contentious among certain scientific groups (see page 46 of the meeting report).[104]

Other Hazardous Chemicals and Waste. Following a similar strategy, producers continue to obstruct the inclusion of asbestos and the herbicide paraquat in the Rotterdam Convention, despite clear recommendations on inclusion by the scientific body of the Convention.[69,105] Further, in the case of asbestos, the chemical industry attempted to influence the decision of the authorities through a filmmaker who had been commissioned by the WHO to film the fate of asbestos victims in India. The filmmaker was actually a covert agent for the corporate intelligence firm K2 and used his role to infiltrate on-the-ground movements, secretly reporting strategies and developments back to the chemical industry. Only in the aftermath was it revealed that the filmmaker was paid by industry.[106]

As another example, in northern Chile, large quantities of hazardous waste have been dumped. Victims of this public health disaster living near the dump site took their case to the Swedish court against a Swedish metal production company responsible for the waste disposal. The hired scientists with COI cast doubt on causation,[107] and the court finally ruled that the health effects reported by Chilean victims were not caused by exposure to the toxic metal-containing waste.[69]

5. AVAILABILITY AND USEFULNESS OF CHEMICAL INDUSTRY DATA FOR THE SPP?

It has been argued that the chemical industry's direct participation in the SPP's work (e.g., conducting assessments) should be encouraged and supported because the chemical industry is often in possession of data that are necessary for such work. We challenge this assertion by discussing it from the perspective of (1) data generation and compilation mechanisms, (2) accessibility of industry data, (3) reliability of industry data, and (4) relevance of industry data for the SPP.

With regard to data generation and compilation, demand for such data is driven by chemical legislation that, depending on the jurisdiction, can require data to gain approval for, e.g., introducing a new chemical to the market or substantially changing a chemical's use.[108] Data requirements and responsibility for supplying data (e.g., chemical producers and

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importers vs public authorities) differ substantially according to the specific regulation and jurisdiction. Many jurisdictions, especially in low- and middle-income countries, do not have the capacity to generate data and thus often rely on data generated in other jurisdictions.

Regulatory demand for data has promoted data generation by industry and the public sector, as well as development of data estimation programs and repositories supported by public entities with examples here of the U.S. EPA's estimation programs for chemical properties and environmental fate, EPISuite, as well as CompTox, the IRIS database, and the OECD eChemPortal, which are used worldwide. These platforms also contain data collected from the literature and thus could be from industry or non-industry sources (contributions of data from individual sources are not publicly tracked). Thus, contributions of data from industry beyond regulatory compliance are not publicly known. Data in these compilations are vetted to a limited extent.

In terms of data accessibility, several high-profile cases of industry suppressing important data have come to light through court cases, such as with polychlorinated biphenyls (PCBs).[37] The case of PFASs provides further evidence of data suppression (see above). For example, studies on population exposures and toxicity were not released to the public until after the year 2000, decades after the company had identified the potential environmental and human health hazards.[109,110]

Furthermore, industry data submitted within the regulatory system may be accompanied by restrictions on how the data can be used and shared (e.g., confidential business information claims severely restrict public access to industry data). Lack of transparency (public data access) is an identified concern, eroding trust in the decision making process. For example, while the EU REACH regulation has substantial data reporting requirements for the chemical industry when new chemicals are registered for use, strengthening public access to such data was again emphasized in the EU Chemicals Strategy for Sustainability, stating the importance of providing access to data by "extending the principle of open data and the relevant transparency principles from the EU food safety sector to other pieces of chemical legislation".[19] Similarly, in accordance with the Strategic Approach to International Chemicals Management (SAICM), a global multistakeholder policy framework in which the chemical industry participates, "information on chemicals relating to the health and safety of humans and the environment should not be regarded as confidential".[111] However, in the evaluation of SAICM, strong concerns regarding the lack of information sharing by the industry were flagged, particularly in relation to Issues Of Concern such as chemicals in products, hazardous substances within the life cycle of electrical and electronic products, and manufactured nanomaterials.[112] Overall, it is currently difficult to assess the extent to which the various industries comply with the far-reaching obligations for information disclosure,[67,68] as there are no systematic means to validate this in the public domain.

In terms of reliability, data provided by industry within chemical legislation have been questioned in terms of compliance, quality, and usefulness for risk-reduction measures.[113−116] A large, systematic evaluation of EU REACH registration dossiers revealed that the chemical industry often failed to comply with the data requirements. Of 1932 dossiers of chemicals produced or imported to the EU in amounts of >1000 tonnes per year, only one dossier complied with the requirements for all end points.[112] When 1814 registration dossiers for chemicals produced or imported in amounts of >1000 tonnes per year were evaluated focusing on the industry's use of data waiving and adaptations, 12−61% of the data sets for an end point lacked basic data or a need for amendment was identified.[113] When the availability and quality of toxicological and ecotoxicological data in 500 registration dossiers for chemicals produced or imported in amounts between 100 and 1000 tonnes per year were evaluated, it was concluded that at least 24% of the assessed end point entries failed to comply with the regulation.[114,115]

Are industry-generated data relevant to the SPP? Data submitted under chemical regulations are, among others, physicochemical, toxicological, and ecotoxicological data. While these data support the hazard and risk assessment of individual substances, other types of data are probably more relevant for the type of assessments the SPP most likely will perform. These data need to include those from monitoring the spatial distribution and time trends of chemicals in the environment, data on accumulation in biota, human biomonitoring data, as well as data on socio-economic impacts, industrial production, and use volumes.

In summary, the direct involvement of the chemical industry in the work of the SPP (by, e.g., carrying out assessments) is not justified by the mere fact that the industry possesses certain data. Rather, form follows function. It is important to have a clear understanding of what data industry possesses and can share in an open and transparent manner and how such data can contribute to the work of the SPP. Given that observers, such as the chemical industry, can contribute by sharing data within IPCC and IPBES, such a mechanism should also be open for data sharing in the work of the SPP.

6. RECOMMENDATIONS TO PROTECT THE SPP FROM CONFLICTS OF INTEREST

Ample evidence shows, as summarized above, that certain industries with COI have unduly influenced numerous policy and regulatory initiatives aimed at protecting human and ecosystem health from harmful chemicals, waste, and pollution. Such influence is of particular concern as the intergovernmental SPP on chemicals, waste, and pollution prevention is being established. In this regard, we have presented evidence that refutes the argument that the chemical industry should be directly involved in the SPP's core work because it holds important data needed for the SPP to achieve its objectives. To protect the SPP from COI, we recommend the following actionable measures.

First, rigorous COI provisions need to be defined and then strictly enforced for all experts.[117] This is key for creating clear and transparent criteria for appointing scientists as experts within the SPP. Experts with a COI should not be allowed to participate in the decision making process or the core work of the SPP (e.g., writing assessments) but may still contribute to the SPP's work as observers.

Second, within the COI provisions of the SPP, financial or political conflicts of interests should not be confused with legitimate interests. Claiming that scientists working in the public sector "also have interests or biases" is one of the manipulation tactics often used to discredit these scientists. Rather, these interests do not include "direct and material gain" in a certain outcome and, as such, do not constitute COIs because they do not distort the scientists' view in the same way as financial or political COIs do.[23]

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Third, we propose that the SPP's work should be regularly monitored by an independent audit team that will conduct two types of audits: (1) regular audits that review compliance with the SPP's COI rules, identify risks and weaknesses in processes and procedures, document deviations, and then recommend corrective measures to be considered by the SPP's governing body and (2) audits of the SPP's outputs to ensure that they are transparent, impartial, credible, and scientifically robust, as mandated by UNEA Resolution 5/8. It should be noted that audits should not be used as a means to unduly delay the SPP's activities but rather to support the SPP's work as a way of promoting a culture of high-quality assessments (e.g., by establishing auditing examples to guide subsequent assessments and other functions).[118,119] Such audits could be done on a random or rotating basis to minimize delays.

Finally, we submit that the SPP assessments should aspire to routinely include as many elements of transparency as possible. The SPP should become a vigorous proponent of the FAIR[120] and CARE[121] principles for scientific data management and stewardship. Further, the SPP should facilitate contributions from actors in the private sector and other interested parties who own and express interest in sharing data.

In summary, our four recommendations include the following:

(i) Provide clear and strict COI provisions.
(ii) Do not confuse conflicts of financial or political competing interests with legitimate interests or biases.
(iii) Install regular audits of the SPP's work.
(iv) Secure as many elements of transparency as possible.

Beyond the SPP, it is important to enhance efforts to educate policy makers, the public, and students about aspects, consequences, and the history of COI. Collectively, these measures should help usher in a global system change in which the presumption of "innocence" of chemicals, waste, and pollution is replaced by a rigorous and proactive framework allowing for effective and efficient assessment and management of chemicals, waste, and pollution to the benefit of society and the environment.

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The authors declare no competing financial interest.
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REFERENCES

(1) Wang, Z. Y.; Walker, G. W.; Muir, D. C. G.; Nagatani-Yoshida, K. Toward a Global Understanding of Chemical Pollution: A First Comprehensive Analysis of National and Regional Chemical Inventories. *Environ. Sci. Technol.* **2020**, *54* (5), 2575−2584.
(2) Cousins, I. T.; Johansson, J. H.; Salter, M. E.; Sha, B.; Scheringer, M. Outside the Safe Operating Space of a New Planetary Boundary for Per- and Polyfluoroalkyl Substances (PFAS). *Environ. Sci. Technol.* **2022**, *56* (16), 11172−11179.
(3) Persson, L.; Carney Almroth, B. M.; Collins, C. D.; Cornell, S.; de Wit, C. A.; Diamond, M. L.; Fantke, P.; Hassellöv, M.; MacLeod, M.; Ryberg, M. W.; et al. Outside the safe operating space of the planetary boundary for novel entities. *Environ. Sci. Technol.* **2022**, *56* (3), 1510−1521.
(4) Anonymous. Managing the systemic use of chemicals in Europe. European Environment Agency - Briefing 2023. https://www.eea.europa.eu/publications/managing-the-systemic-use-of (accessed 2023-05-29).
(5) Naidu, R.; Biswas, B.; Willett, I. R.; Cribb, J.; Kumar Singh, B.; Paul Nathanail, C.; Coulon, F.; Semple, K. T.; Jones, K. C.; Barclay, A.; et al. Chemical pollution: A growing peril and potential catastrophic risk to humanity. *Environ. Int.* **2021**, *156*, 106616.
(6) Moller, A.; Xie, Z. Y.; Cai, M. H.; Zhong, G. C.; Huang, P.; Cai, M. G.; Sturm, R.; He, J. F.; Ebinghaus, R. Polybrominated Diphenyl Ethers vs Alternate Brominated Flame Retardants and Dechloranes from East Asia to the Arctic. *Environ. Sci. Technol.* **2011**, *45* (16), 6793−6799.
(7) Napper, I. E.; Davies, B. F. R.; Clifford, H.; Elvin, S.; Koldewey, H. J.; Mayewski, P. A.; Miner, K. R.; Potocki, M.; Elmore, A. C.; Gajurel, A. P.; et al. Reaching New Heights in Plastic Pollution-Preliminary Findings of Microplastics on Mount Everest. *One Earth* **2020**, *3* (5), 621−630.
(8) Jamieson, A. J.; Malkocs, T.; Piertney, S. B.; Fujii, T.; Zhang, Z. L. Bioaccumulation of persistent organic pollutants in the deepest ocean fauna. *Nat. Ecol. Evol.* **2017**, *1* (3), 0051.
(9) Guzzella, L.; Salerno, F.; Freppaz, M.; Roscioli, C.; Pisanello, F.; Poma, G. POP and PAH contamination in the southern slopes of Mt. Everest (Himalaya, Nepal): Long-range atmospheric transport, glacier shrinkage, or local impact of tourism? *Sci. Total Environ.* **2016**, *544*, 382−390.
(10) Anonymous. What a Waste 2.0 - A Global Snapshot of Solid Waste Management to 2050. The World Bank, 2023. https://datatopics.worldbank.org/what-a-waste/ (accessed 2023-05-27).
(11) Wilkinson, J. L.; Boxall, A. B. A.; Kolpin, D. W.; Leung, K. M. Y.; Lai, R. W. S.; Galban-Malagon, C.; Adell, A. D.; Mondon, J.; Metian, M.; Marchant, R. A.; et al. Pharmaceutical pollution of the world's rivers. *Proc. Natl. Acad. Sci. U. S. A.* **2022**, *119* (8), e2113947119.
(12) Kidd, K. A.; Blanchfield, P. J.; Mills, K. H.; Palace, V. P.; Evans, R. E.; Lazorchak, J. M.; Flick, R. W. Collapse of a fish population after exposure to a synthetic estrogen. *Proc. Natl. Acad. Sci. U. S. A.* **2007**, *104* (21), 8897−8901.
(13) Malaj, E.; von der Ohe, P. C.; Grote, M.; Kuhne, R.; Mondy, C. P.; Usseglio-Polatera, P.; Brack, W.; Schafer, R. B. Organic chemicals jeopardize the health of freshwater ecosystems on the continental scale. *Proc. Natl. Acad. Sci. U. S. A.* **2014**, *111* (26), 9549−9554.
(14) Fuller, R.; Landrigan, P. J.; Balakrishnan, K.; Bathan, G.; Bose-O'Reilly, S.; Brauer, M.; Caravanos, J.; Chiles, T.; Cohen, A.; Corra, L.; et al. Pollution and health: a progress update. *Lancet Planet. Health* **2022**, *6* (6), E535−E547.
(15) Landrigan, P. J.; Fuller, R.; Acosta, N. J. R.; Adeyi, O.; Arnold, R.; Basu, N.; Balde, A. B.; Bertollini, R.; Bose-O'Reilly, S.; Boufford, J. I.; et al. The Lancet Commission on pollution and health. *Lancet* **2018**, *391* (10119), 462−512.
(16) Wang, Z. Y.; Altenburger, R.; Backhaus, T.; Covaci, A.; Diamond, M. L.; Grimalt, J. O.; Lohmann, R.; Schaffer, A.; Scheringer, M.; Selin, H.; et al. We need a global science-policy body on chemicals and waste. *Science* **2021**, *371* (6531), 774−776.
(17) UNEP. Resolution adopted by the United Nations Environment Assembly on 2 March 2022 - Science-policy panel to contribute further to the sound management of chemicals and waste and to prevent pollution. 2022. https://wedocs.unep.org/bitstream/handle/20.500.11822/39846/SOUND%20MANAGEMENT%20OF%20CHEMICALS%20AND%20WASTE.%20English.pdf?sequence=1&isAllowed=y.
(18) Anonymous. The Importance of Chemical Research to the U.S. Economy. National Academies of Sciences, Engineering, and Medicine, 2022..
(19) European Commission. Chemicals Strategy for Sustainability. Towards a Toxic-Free Environment. 2020, 24.http://www.saicm.org/Portals/12/Documents/saicmtexts/New%20SAICM%20Text%20with%20ICCM%20resolutions_E.pdf.
(20) Anonymous. From dump site to the heart of a community. Global Environmental Facility (GEF), 2023. https://www.thegef.org/ (accessed 2023-05-20).
(21) Schenk, L.; Johanson, G. Management of bias and conflict of interest among occupational exposure limit expert groups. *Regul. Toxicol. Pharmacol.* **2021**, *123*, 104929.
(22) IPCC. IPCC Conflict of interest policy. 2016. https://www.ipcc.ch/site/assets/uploads/2018/09/ipcc-conflict-of-interest-2016.pdf.
(23) Bero, L. A.; Grundy, Q. Why Having a (Nonfinancial) Interest Is Not a Conflict of Interest. *PLoS Biol.* **2016**, *14* (12), No. e2001221.
(24) Resnik, D. Disclosing and managing non-financial conflicts of interest in scientific publications. *Res. Ethics* **2023**, *19* (2), 121−138.
(25) Komesaroff, P. A.; Kerridge, I.; Lipworth, W. Conflicts of interest: new thinking, new processes. *Intern. Med. J.* **2019**, *49* (5), 574−577.
(26) Andersen, M. S.; Clubb, D. O. Understanding and accounting for the costs of inaction. Chapter 23. In *Late lessons from early warnings: science, precaution, innovation*; European Environment Agency, 2013; pp 564−580.
(27) Goldberg, R. F.; Vandenberg, L. N. The science of spin: targeted strategies to manufacture doubt with detrimental effects on environmental and public health. *Environ. Health* **2021**, *20* (1), 33 DOI: 10.1186/s12940-021-00723-0.
(28) Chan, G.; Carraro, C.; Edenhofer, O.; Kolstad, C.; Stavins, R. Reforming the IPCC's assessment of climate change economics. *Clim. Chang. Econ.* **2016**, *7* (1), 1640001.
(29) Michaels, D. *Doubt is their product*; Oxford University Press, 2008. https://global.oup.com/academic/product/doubt-is-their-product-9780195300673?cc=de&lang=en&.
(30) Oreskes, N.; Conway, E. M. *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*; Bloomsbury Press, 2010. https://books.google.de/books?id=fpMh3nh3JI0C&pg=PP4&redir_esc=y#v=onepage&q&f=false.
(31) Goldberg, R. F.; Vandenberg, L. N. Distract, delay, disrupt: examples of manufactured doubt from five industries. *Rev. Environ. Health* **2019**, *34* (4), 349−363.
(32) Mann, M. E. *Hockey Stick and the Climate Wars: Dispatches from the Front Lines*; Columbia University Press, 2013. https://academic.oup.com/columbia-scholarship-online/book/13972.
(33) Waldman, S.; Heikkinen, N. As climate scientists speak out, sexist attacks are on the rise. *Sci. Am.* **2018**, August 22. https://www.scientificamerican.com/article/as-climate-scientists-speak-out-sexist-attacks-are-on-the-rise/ (accessed 2023-05-29).
(34) Milman, O. Climate scientists face harassment, threats and fears of 'McCarthyist attacks'. *The Guardian* **2017**, February 22. https://www.theguardian.com/environment/2017/feb/22/climate-change-science-attacks-threats-trump (accessed 2023-05-28).
(35) Aviv, R. A valuable reputation. *The New Yorker - Annals of Science* **2014**, February 10. https://www.newyorker.com/magazine/2014/02/10/a-valuable-reputation (accessed 2023-05-22).

https://doi.org/10.1021/acs.est.3c04213
Environ. Sci. Technol. 2023, 57, 19066−19077

(36) Ong, E. K.; Glantz, S. A. Constructing "sound science" and "good epidemiology": Tobacco, lawyers, and public relations firms. *Am. J. Public Health* **2001**, *91* (11), 1749−1757.
(37) Markowitz, G.; Rosner, D. Monsanto, PCBs, and the creation of a "world-wide ecological problem". *J. Public Health Policy* **2018**, *39* (4), 463−540.
(38) Campbell, J.; Clewell, H.; Cox, T.; Dourson, M.; Ethridge, S.; Forsberg, N.; Gadagbui, B.; Hamade, A.; Naidu, R.; Pechacek, N.; et al. The Conundrum of the PFOA human half-life, an international collaboration. *Regul. Toxicol. Pharmacol.* **2022**, *132*, 105185.
(39) Campbell, J.; Clewell, H.; Cox, T.; Dourson, M.; Ethridge, S.; Forsberg, N.; Gadagbui, B.; Hamade, A.; Naidu, R.; Pechacek, N.; et al. Response to letter to editor "letter to the editors regarding "the Conundrum of the PFOA human half-life, an international collaboration". *Regul. Toxicol. Pharmacol.* **2022**, *134*, 105246.
(40) Post, G. B.; Birnbaum, L. S.; DeWitt, J. C.; Goeden, H.; Heiger-Bernays, W. J.; Schlezinger, J. J. Letter to the editors regarding "The conundrum of the PFOA human half-life, an international collaboration". *Regul. Toxicol. Pharmacol.* **2022**, *134*, 105240.
(41) Stecula, D. A.; Merkley, E. Framing Climate Change: Economics, Ideology, and Uncertainty in American News Media Content From 1988 to 2014. *Front. Commun.* **2019**, *4*, 6 DOI: 10.3389/fcomm.2019.00006.
(42) Maani, N.; Van Schalkwyk, M. C. I.; Filippidis, F. T.; Knai, C.; Petticrew, M. Manufacturing doubt: Assessing the effects of independent vs industry-sponsored messaging about the harms of fossil fuels, smoking, alcohol, and sugar sweetened beverages. *SSM-Popul. Health* **2022**, *17*, 101009.
(43) Barnes, D. E.; Bero, L. A. Why review articles on the health effects of passive smoking reach different conclusions. *JAMA* **1998**, *279* (19), 1566−1570.
(44) Bero, L. A. Tobacco industry manipulation of research. *Public Health Rep.* **2005**, *120* (2), 200−208.
(45) Miller, J.; Vijayaraghavan, M. Tobacco Industry Efforts to Respond to Smoke-Free Policies in Multi-Unit Housing: An Evaluation of Tobacco Industry Documents. *Int. J. Environ. Res. Public Health* **2022**, *19* (5), 3053.
(46) Pisinger, C.; Godtfredsen, N.; Bender, A. M. A conflict of interest is strongly associated with tobacco industry-favourable results, indicating no harm of e-cigarettes. *Prev. Med.* **2019**, *119*, 124−131.
(47) Martinez, C.; Fu, M.; Galan, I.; Perez-Rios, M.; Martinez-Sanchez, J. M.; Lopez, M. J.; Sureda, X.; Montes, A.; Fernandez, E. Conflicts of interest in research on electronic cigarettes. *Tob. Induced Dis.* **2018**, *16*, 28 DOI: 10.18332/tid/90668.
(48) Vartanian, L. R.; Schwartz, M. B.; Brownell, K. D. Effects of Soft Drink Consumption on Nutrition and Health: A Systematic Review and Meta-Analysis. *Am. J. Public Health* **2007**, *97* (4), 667−675.
(49) Bes-Rastrollo, M.; Schulze, M. B.; Ruiz-Canela, M.; Martinez-Gonzalez, M. A. Financial Conflicts of Interest and Reporting Bias Regarding the Association between Sugar-Sweetened Beverages and Weight Gain: A Systematic Review of Systematic Reviews. *PLoS Med.* **2013**, *10* (12), e1001578.
(50) Zaltz, D. A.; Bisi, L. E.; Ruskin, G.; Hoe, C. How independent is the international food information council from the food and beverage industry? A content analysis of internal industry documents. *Global. Health* **2022**, *18* (1), 91 DOI: 10.1186/s12992-022-00884-8.
(51) Shrader-Frechette, K. Climate Change, Nuclear Economics, and Conflicts of Interest. *Sci. Eng. Ethics* **2011**, *17* (1), 75−107.
(52) Kogevinas, M.; Takaro, T. Sponsorship by Big Oil, Like the Tobacco Industry, Should be Banned by the Research Community. *Epidemiology* **2019**, *30* (5), 615−616.
(53) Supran, G.; Rahmstorf, S.; Oreskes, N. Assessing ExxonMobil's global warming projections. *Science* **2023**, *379* (6628), No. eabk0063.
(54) Almond, D.; Du, X. M.; Papp, A. Favourability towards natural gas relates to funding source of university energy centres. *Nat. Clim. Chang.* **2022**, *12* (12), 1122−1128.
(55) Brezis, M. Big pharma and health care: Unsolvable conflict of interests between private enterprise and public health. *Isr. J. Psychiatry Related Sci.* **2008**, *45* (2), 83−89.
(56) Spithoff, S.; Leece, P.; Sullivan, F.; Persaud, N.; Belesiotis, P.; Steiner, L. Drivers of the opioid crisis: An appraisal of financial conflicts of interest in clinical practice guideline panels at the peak of opioid prescribing. *PLoS One* **2020**, *15* (1), e0227045.
(57) Bekelman, J. E.; Li, Y.; Gross, C. P. Scope and impact of financial conflicts of interest in biomedical research - A systematic review. *JAMA* **2003**, *289* (4), 454−465.
(58) Khan, N. A.; Nguyen, C. L.; Khawar, T.; Spencer, H.; Torralba, K. D. Association of author's financial conflict of interest with characteristics and outcome of rheumatoid arthritis randomized controlled trials. *Rheumatology* **2019**, *58* (5), 776−785.
(59) Jagsi, R.; Sheets, N.; Jankovic, A.; Motomura, A. R.; Amarnath, S.; Ubel, P. A. Frequency, Nature, Effects, and Correlates of Conflicts of Interest in Published Clinical Cancer Research. *Cancer* **2009**, *115* (12), 2783−2791.
(60) Anglemyer, A. T.; Krauth, D.; Bero, L. Industry sponsorship and publication bias among animal studies evaluating the effects of statins on atherosclerosis and bone outcomes: a meta-analysis. *BMC Med. Res. Methodol.* **2015**, *15*, 12 DOI: 10.1186/s12874-015-0008-z.
(61) Bero, L.; Anglemyer, A.; Vesterinen, H.; Krauth, D. The relationship between study sponsorship, risks of bias, and research outcomes in atrazine exposure studies conducted in non-human animals: Systematic review and meta-analysis. *Environ. Int.* **2016**, *92*−*93*, 597−604.
(62) Rocha, G. M.; Grisolia, C. K. Why pesticides with mutagenic, carcinogenic and reproductive risks are registered in Brazil. *Dev. World Bioeth.* **2019**, *19* (3), 148−154.
(63) Jarrell, Z. R.; Ahammad, M. U.; Benson, A. P. Glyphosate-based herbicide formulations and reproductive toxicity in animals. *Vet. Anim. Sci.* **2020**, *10*, 100126.
(64) Mesnage, R.; Benbrook, C.; Antoniou, M. N. Insight into the confusion over surfactant co-formulants in glyphosate-based herbicides. *Food Chem. Toxicol.* **2019**, *128*, 137−145.
(65) Mesnage, R.; Defarge, N.; Spiroux de Vendomois, J.; Seralini, G. E. Potential toxic effects of glyphosate and its commercial formulations below regulatory limits. *Food Chem. Toxicol.* **2015**, *84*, 133−153.
(66) Novotny, E. Glyphosate, Roundup and the Failures of Regulatory Assessment. *Toxics* **2022**, *10* (6), 321.
(67) Mie, A.; Ruden, C. What you don't know can still hurt you − under reporting in EU pesticide regulation. *Environ. Health* **2022**, *21* (1), 79 DOI: 10.1186/s12940-022-00891-7.
(68) Mie, A.; Rudén, C. Non-disclosure of developmental neurotoxicity studies obstructs the safety assessment of pesticides in the European Union. *Environ. Health* **2023**, *22*, 44 DOI: 10.1186/s12940-023-00994-9.
(69) IPCP. Webinar: Unwrapping Conflict of Interest in Chemicals and Waste Governance. 2023, January 26. https://www.ipcp.ch/activities/webinar-unwrapping-conflict-of-interest-in-chemicals-and-waste-governance (accessed 2023-05-26).
(70) MacLeod, M.; Arp, H. P. H.; Tekman, M. B.; Jahnke, A. The global threat from plastic pollution. *Science* **2021**, *373* (6550), 61−65.
(71) Beaumont, N. J.; Aanesen, M.; Austen, M. C.; Borger, T.; Clark, J. R.; Cole, M.; Hooper, T.; Lindeque, P. K.; Pasco, C.; Wyles, K. J. Global ecological, social and economic impacts of marine plastic. *Mar. Pollut. Bull.* **2019**, *142*, 189−195.
(72) Wilcox, C.; Van Sebille, E.; Hardesty, B. D. Threat of plastic pollution to seabirds is global, pervasive, and increasing. *Proc. Natl. Acad. Sci. U. S. A.* **2015**, *112* (38), 11899−11904.
(73) Neira, M. The Minderoo-Monaco Commission on Plastics and Human Health. *Ann. Glob. Health* **2023**, *89* (1), 1−2.
(74) Mah, A. *Plastic Unlimited: How Corporations Are Fuelling the Ecological Crisis and What We Can Do About It*; Wiley, 2022.
(75) da Costa, J. P. Micro-consumerist bollocks in the fight against plastic pollution: when good intentions - and regulatory initiatives - go awry. *Water Emerg. Contam. Nanoplastics* **2023**, *2* (1), 7.
(76) Shipton, L.; Dauvergne, P. Health concerns of plastics: energizing the global diffusion of anti-plastic norms. *J. Environ. Plan. Manag.* **2022**, *65* (11), 2124−2144.

(77) Anonymous. Plastics Europe - Sustainability. 2023. https://plasticseurope.org/sustainability/ (accessed 2023-05-29).
(78) Anonymous. Daily report for 1 December 2022: 1st Session of the Intergovernmental Negotiating Committee to develop an international legally binding instrument on plastic pollution, including in the marine environment (INC-1). *IISD Earth Negotiations Bulletin* **2022**, December 1. https://enb.iisd.org/plastic-pollution-marine-environment-negotiating-committee-inc1-daily-report-1dec2022.
(79) Anonymous. WHO: stop tobacco industry interference. WHO News Release 2012, May 30. https://www.who.int/news/item/30-05-2012-who-stop-tobacco-industry-interference (accessed 2023-05-29).
(80) Geddie, J.; Volcovici, V.; Brock, J. U.N. pact may restrict plastic production. Big Oil aims to stop it. REUTERS press release 2022, February 18. https://www.reuters.com/business/sustainable-business/un-pact-may-restrict-plastic-production-big-oil-aims-stop-it-2022-02-18/ (accessed 2023-05-20).
(81) McGreal, C. How a powerful US lobby group helps big oil to block climate action. *The Guardian* **2021**, July 19. https://www.theguardian.com/environment/2021/jul/19/big-oil-climate-crisis-lobby-group-api (accessed 2023-05-21).
(82) Bell, L.; Todoran, G. S. Plastic bag legislation in the United States: influential factors on its creation. *J. Environ. Stud. Sci.* **2022**, *12* (2), 260−271.
(83) Wang, Z. Y.; Praetorius, A. Integrating a Chemicals Perspective into the Global Plastic Treaty. *Environ. Sci. Technol. Lett.* **2022**, *9* (12), 1000−1006.
(84) Harris, L. Inside the chemical lobby's unusual campaign to protect the fire retardant business. *New York Focus* **2021**, May 22. https://www.nysfocus.com/2021/05/22/chemicals-lobby-campaign/ (accessed 2023-05-28).
(85) Blades, J.; Gable, J. Flame retardants in your earbuds? Toxic chemicals in homes? Left and right are sick of It. *FULCRUM* **2023**, January 31. https://thefulcrum.us/government-regulations-aiding-special-interests (accessed 2023-05-28).
(86) DiGangi, J.; Blum, A.; Bergman, A.; de Wit, C. A.; Lucas, D.; Mortimer, D.; Schecter, A.; Scheringer, M.; Shaw, S. D.; Webster, T. F. San Antonio Statement on Brominated and Chlorinated Flame Retardants. *Environ. Health Perspect.* **2010**, *118* (12), A516−A518.
(87) Yang, C. Q.; Jilkova, S. R.; Melymuk, L.; Harris, S. A.; Jantunen, L. M.; Pertili, J.; Winn, L.; Diamond, M. L. Are We Exposed to Halogenated Flame Retardants from both Primary and Secondary Sources? *Environ. Sci. Technol. Lett.* **2020**, *7* (8), 585−593.
(88) Charbonnet, J. A.; Weber, R.; Blum, A. Flammability standards for furniture, building insulation and electronics: Benefit and risk. *Emerg. Contam.* **2020**, *6*, 432−441.
(89) Anonymous. Chemical companies, Big Tobacco and the toxic products in your home. *Tribune Watchdog* **2014**. https://media.apps.chicagotribune.com/flames/index.html (accessed 2023-05-22).
(90) Alcock, R. E.; Busby, J. Risk migration and scientific advance: The case of flame-retardant compounds. *Risk Anal.* **2006**, *26* (2), 369−381.
(91) Steenland, K.; Hofmann, J. N.; Silverman, D. T.; Bartell, S. M. Risk assessment for PFOA and kidney cancer based on a pooled analysis of two studies. *Environ. Int.* **2022**, *167*, 107425.
(92) Lerner, S. 3M Knew About the Dangers of PFOA and PFOS Decades Ago, Internal Documents Show. *The Intercept* **2018**. https://theintercept.com/2018/07/31/3m-pfas-minnesota-pfoa-pfos/ (accessed 2023-05-23).
(93) Lerner, S. Lawsuit Reveals How Paid Expert Helped 3M "Command the Science" on Dangerous Chemicals. *The Intercept* **2018**. https://theintercept.com/2018/02/23/3m-lawsuit-pfcs-pollution/ (accessed 2023-05-25).
(94) Billott, R. *Exposure*; Simon & Schuster, 2020.
(95) Lohmann, R.; Cousins, I. T.; DeWitt, J. C.; Gluge, J.; Goldenman, G.; Herzke, D.; Lindstrom, A. B.; Miller, M. F.; Ng, C. A.; Patton, S.; et al. Are Fluoropolymers Really of Low Concern for Human and Environmental Health and Separate from Other PFAS? *Environ. Sci. Technol.* **2020**, *54* (20), 12820−12828.
(96) Korzeniowski, S. H.; Buck, R. C.; Newkold, R. M.; El Kassmi, A.; Laganis, E.; Matsuoka, Y.; Dinelli, B.; Beauchet, S.; Adamsky, F.; Weilandt, K.; et al. A critical review of the application of polymer of low concern regulatory criteria to fluoropolymers II: Fluoroplastics and fluoroelastomers. *Integr. Environ. Assess. Manag.* **2023**, *19*, 326−354.
(97) Gebbink, W. A.; van Asseldonk, L.; van Leeuwen, S. P. J. Presence of Emerging Per- and Polyfluoroalkyl Substances (PFASs) in River and Drinking Water near a Fluorochemical Production Plant in the Netherlands. *Environ. Sci. Technol.* **2017**, *51* (19), 11057−11065.
(98) Gebbink, W. A.; van Leeuwen, S. P. J. Environmental contamination and human exposure to PFASs near a fluorochemical production plant: Review of historic and current PFOA and GenX contamination in the Netherlands. *Environ. Int.* **2020**, *137*, 105583.
(99) Valsecchi, S. A tale of PFAS, pollution, and patent claims. *C&EN* **2023**. https://cen.acs.org/analytical-chemistry/A-tale-of-PFAS-pollution-and-patent-claims/99/i11 (accessed 2023-05-19).
(100) Herrick, R. L.; Buckholz, J.; Biro, F. M.; Calafat, A. M.; Ye, X. Y.; Xie, C. C.; Pinney, S. M. Polyfluoroalkyl substance exposure in the Mid-Ohio River Valley, 1991−2012. *Environ. Pollut.* **2017**, *228*, 50−60.
(101) Fromme, H.; Wockner, M.; Roscher, E.; Volkel, W. ADONA and perfluoroalkylated substances in plasma samples of German blood donors living in South Germany. *Int. J. Hyg. Environ. Health* **2017**, *220* (2), 455−460.
(102) Bergman, A.; Becher, G.; Blumberg, B.; Bjerregaard, P.; Bornman, R.; Brandt, I.; Casey, S. C.; Frouin, H.; Giudice, L. C.; Heindel, J. J.; et al. Manufacturing doubt about endocrine disrupter science - A rebuttal of industry-sponsored critical comments on the UNEP/WHO report "State of the Science of Endocrine Disrupting Chemicals 2012". *Regul. Toxicol. Pharmacol.* **2015**, *73* (3), 1007−1017.
(103) Bergman, Å.; Heindel, J. J.; Jobling, S.; Kidd, K. A.; Zoeller, R. T. State of the Science of Endocrine Disrupting Chemicals - 2012. World Health Organization2012, p 289. https://www.unep.org/resources/publication/state-science-endocrine-disputing-chemicals-ipcp-2012.
(104) SAICM. Report of the International Conference on Chemicals Management on the work of its fourth session. 2015, SAICM/ICCM.4/15, 62. http://saicm.org/Portals/12/documents/meetings/ICCM4/doc/K1606013_e.pdf.
(105) Blumenthal, J.; Diamond, M. L.; Hoffmann, M.; Wang, Z. Y. Time to Break the "Lock-In" Impediments to Chemicals Management. *Environ. Sci. Technol.* **2022**, *56* (7), 3863−3870.
(106) Anonymous. Corporate surveillance: 'Substantial' payout in asbestos spying scandal. *Hazards Magazine* **2018**, 144. https://www.hazards.org/asbestos/ispy.htm (accessed 2023-05-15).
(107) Simon. Acclaimed 'Arica' documentary prompts intervention from United Nations Human Rights Council (UNHRC). *Toxic Justice* **2023**. http://toxicjustice.org/acclaimed-arica-documentary-prompts-intervention-from-united-nations-human-rights-council-unhrc/ (accessed 2023-05-18).
(108) Breithaupt, H. The costs of REACH - REACH is largely welcomed, but the requirement to test existing chemicals for adverse effects is not good news for all. *Embo Rep.* **2006**, *7* (10), 968−971.
(109) Lerner, S. How DuPont slipped past the EPA. *The Intercept* **2015**, August 20. https://theintercept.com/2015/08/20/teflon-toxin-dupont-slipped-past-epa/ (accessed 2023-05-12).
(110) Gaber, N.; Bero, L.; Woodruff, T. J. The devil they knew: Chemical documents analysis of industry influence on PFAS science. *Ann. Glob. Health* **2023**, *89* (1), 1−17.
(111) UNEP. Article 22 of the Dubai declaration on international Chemical Management. http://www.saicm.org/Portals/12/Documents/saicmtexts/New%20SAICM%20Text%20with%20ICCM%20resolutions_E.pdf. 2006, 195.
(112) Nurick, R. Final Report: Independent Evaluation of the Strategic Approach from 2006−2015. 2019, p 94. http://www.saicm.org/Portals/12/Documents/reporting/FinalReport_Independent-Evaluation-SAICM-2006-2015.pdf (accessed 2023-05-29).

https://doi.org/10.1021/acs.est.3c04213
Environ. Sci. Technol. 2023, 57, 19066−19077

(113) Springer, A.; Herrmann, H.; Sittner, D.; Herbst, U.; Schulte, A. REACH Compliance: Data Availability of REACH Registrations - Part 1: Screening of chemicals > 1000 tpa. German Environment Agency, 2015, *43*, 185. https://www.umweltbundesamt.de/en/publikationen/reach-compliance-data-availability-of-reach.
(114) Oertel, A.; Maul, K.; Menz, J.; Kronsbein, A. L.; Sittner, D.; Springer, A.; Müller, A.-K.; Herbst, U.; Schlegel, K.; Schulte, A. REACH Compliance: Data availability in REACH registrations Part 2: Evaluation of data waiving and adaptations for chemicals ≥ 1000 tpa. German Environment Agency, 2018, *64*, 205. https://www.umweltbundesamt.de/en/publikationen/reach-compliance-data-availability-in-reach.
(115) Oertel, A.; Menz, J.; Brüning, A.; Schmeisser, S.; Kronsbein, A. L.; Maul, K.; Heinze, P.; Schulte, A. REACH Compliance: Data availability in REACH registrations − Part 3: Evaluation of 100 to 1000 tpa substances. German Environment Agency 2020, *39*, 182. https://www.umweltbundesamt.de/en/publikationen/reach-compliance-data-availability-in-reach-0.
(116) Borchert, F.; Beronius, A.; Agerstrand, M. Characterisation and analysis of key studies used to restrict substances under REACH. *Environ. Sci. Eur.* **2022**, *34* (1), 83 DOI: 10.1186/s12302-022-00662-8.
(117) Ågerstrand, M.; Arinaitwe, K.; Backhaus, T.; Barra, R. O.; Diamond, M. L.; Grimalt, J. O.; Groh, K.; Kandie, F.; Kurt-Karakus, P. B.; Letcher, R. J.; Lohmann, R.; et al. Key Principles for the Intergovernmental Science−Policy Panel on Chemicals and Waste. *Environ. Sci. Technol.* **2023**, *57* (6), 2205−2208.
(118) Anonymous. Performance audit. *Aware* **2023**. https://methodology.eca.europa.eu/aware/PA/Pages/default.aspx (accessed 2023-05-20).
(119) Anonymous. Enhancing Global Environmental Benefits through Excellence in Evaluation. Independent Evaluation Office (IEO), 2023. https://www.gefieo.org/about-us (accessed 2023-05-22).
(120) Wilkinson, M. D.; Dumontier, M.; Aalbersberg, I. J.; Appleton, G.; Axton, M.; Baak, A.; Blomberg, N.; Boiten, J. W.; da Silva Santos, L. B.; Bourne, P. E.; et al. The FAIR Guiding Principles for scientific data management and stewardship. *Sci. Data* **2016**, *3*, 160018.
(121) Anonymous. CARE principles for indigenous data governance. 2023. https://www.gida-global.org/care (accessed 2023-05-27).

https://doi.org/10.1021/acs.est.3c04213
Environ. Sci. Technol. 2023, 57, 19066−19077