Uppsala HEALTH SUMMIT

Pre-Conference Report

Chemical Pollution and One Health

From Reactivity to Proactivity

Uppsala 24–25 October 2023

#UppsalaHealthSummit

Uppsala Health Summit is an international forum for frank dialogue between decision-makers, experts, and advocates on global health challenges. Each year, invited participants gather to explore how to implement research and innovation for better health globally.

The summit is a collaborative effort led by Uppsala University, which includes the Swedish University of Agricultural Sciences, Uppsala Region, the Medical Products Agency, the National Veterinary Institute, the City of Uppsala, and Örebro University.

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Foreword

Chemical pollution is on a par with climate change and biodiversity loss as one of our greatest planetary challenges. It poses a threat to human and animal health as well as the environment. We know that it can take years or longer for the damage to reveal itself, but when it does, the effects of harmful chemical exposure are often severe and long-lasting. In humans, these effects are typically observed in the form of chronic disease, infertility and metabolic and neurological disorders.

Nonetheless, our production of toxic chemicals, including those in plastics, is projected to rise and to be used in increasingly complex mixtures that are difficult to assess and therefor to regulate.

As a chemist, I know we need to ask ourselves what actions should be prioritized to protect health, who should be involved, and what responsibilities they should have, as well as how the science on chemicals and health can be more effectively translated into policies.

It is time we change our response; we must go from being reactive to being proactive.

Uppsala Health Summit was created to bring global actors together to connect science and policy around complex health challenges. As our summit celebrates its 10th anniversary this year, we are proud to take on the difficult topic of chemical pollution. I welcome you to take part in this effort and in our challenging and rewarding discussions!

Anders Hagfeldt
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and Chairman of the Uppsala Health Summit
Steering Committee.

Chemical Pollution and One Health

From Reactivity to Proactivity

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Man-made chemicals are an integral part of life today and have contributed to improving our living standards significantly during the past century. Materials such as rubber and plastic have made everyday life more convenient, pesticides increase our harvests, and pharmaceuticals improve our health. A recent analysis of chemical inventories across the globe uncovered over 350,000 chemicals and mixtures of chemicals that have been registered for production and use[1]. The chemical industry is one of the largest manufacturing industries in the world, developing hundreds of new chemicals every year and repurposing chemicals for new applications. Chemicals in technical applications are commonly complex mixtures of hundreds, thousands, and even more substances. As a result, humans and the environment are constantly exposed to thousands of manmade chemicals via air, water, and food.

The negative impacts of this chemical pollution are severe. In humans, exposure to chemical pollution is linked to a wide range of health impacts, including chronic diseases, metabolic and neurological disorders, and reduced fertility. In fact, pollution is one of the most common causes of premature death[2], and the burden on healthcare systems caused by chemical-exposure-induced chronic diseases is enormous. For endocrine-disrupting chemicals (EDCs) alone, linked health effects are estimated to cost the society about 157 billion Euros annually in Europe and 340 billion annually in the US[3]. Likewise, chemical pollution has profound effects on wildlife health and is one of the important contributors to biodiversity loss. Its negative impact on biodiversity is equal to or perhaps even greater than that of climate change.[4]

Chemical pollution – an overlooked issue

While the research community is continuously presenting new evidence for the hazards and risks posed by chemicals, current evidence is already sufficient to call for immediate action. Still, chemical pollution is flying under the radar and is low on political agendas. One reason for this is that chemical pollution is not visible (in contrast to, e.g., the extreme weather now being experienced as a consequence of climate change), another is that causality between exposure and health effects is difficult to prove. Furthermore, conflicting goals and interests make the issue difficult to navigate. For the powerful chemical industry, the economic benefits of inaction are huge and often prioritized over health aspects in political decisions. But even when human and environmental health is given priority, there are goal conflicts that impede progress. For example, while pharmaceuticals undoubtedly save lives, their presence in the environment poses health risks for wildlife, particularly aquatic species. To feed the human population, current farming depends heavily on pesticide use, which poses health risks for humans and the environment. Moreover, the green transition introduces new hazards into the value chain, e.g., substances such as rare metals whose toxicity is unknown, or recycled products containing hazardous chemicals not intended for use in the recycled items. In our technology- and innovation-driven society, the issue of chemical pollution is most often overlooked, and new

solutions might be circular and sustainable but rarely safe by design.

From reactivity to proactivity

What is needed to minimize the negative impacts of chemical pollution? Most importantly, chemical pollution has to be generally recognized as a threat to the environment and human health and treated with the same urgency as climate change and biodiversity loss. Chemical pollution is partly responsible for climate change and biodiversity loss, and it is critically interlinked with eliminating these threats. Thus, today's planetary-scale emergencies must be seen as a "triple crisis", where chemical pollution plays an equal role and solutions have to be identified in an integrative manner, taking chemical safety into account.

And indeed, during recent years, we have seen some developments in this direction in the policy arena. In 2015, the United Nations (UN) adopted the Sustainable Development Goals (SDGs) as "a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity". Nine of the 17 UN Sustainable Development Goals (SDGs) and targets include issues related to chemical exposure. For examples, Goal 3 (Good Health and Well-Being) includes the target "by 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination"[5]. In 2019, the European Union (EU) adopted the "European Green Deal", an ambitious strategy for transformation towards sustainable development. This was complemented in 2020 with the Chemicals Strategy for Sustainability,[6] which comprises far-reaching measures to achieve a "toxic-free environment". Currently, negotiations within the UNEP are ongoing for "an international legally binding instrument on plastic pollution, including in the marine environment", and hopes are high that this legally binding, global treaty will have a significant impact on plastic and chemical pollution. In July of this year, the Seventh Ministerial Conference on Environment and Health signed the Budapest Declaration,[7] which defines the future environment and health priorities and commitments for the WHO European Region. The declaration commits, among other things, to "prioritize action on the health challenges related to the triple crisis of climate change, environmental pollution, and biodiversity loss, including by strengthening the engagement of the health sector in these agendas and recognizing the centrality of these factors in the global health agenda". And in March 2022, the United Nations Environment Assembly decided to establish the Science-Policy Panel on chemicals, waste and pollution prevention[8], which is analogous to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Intergovernmental Panel on Climate Change (IPCC). Such intergovernmental panels are essential in providing science-based advice on policy actions, and it is thus of great importance that this new panel will be built on key expertise to help prioritize and accelerate actions.

While policy action is the most important step, it is not the only development needed in a move towards safe use of chemicals. To move from reactivity to proactivity, the ultimate aim must be to not release hazardous chemicals at all, as opposed to finding methods to remove them from the environment after they have already had negative impacts on health. This requires, among other things, changes in the criteria used to determine when a chemical is toxic or hazardous. For example, if persistence (high stability) had been a criterion for not putting chemicals on the market, the huge pollution problem with per- and polyfluoroalkyl substances (PFAS), also known as "forever chemicals", could have been prevented. Accordingly, persistence, which is relatively easy to predict, should be introduced as a criterion when assessing a chemical's hazard, the goal being to avoid "forever chemicals" in the environment in the future[9] Yet even if criteria are introduced, identifying hazardous properties is not always that easy. For instance, when the European Commission acknowledged EDCs as substances of particular concern and introduced endocrine disruption as a hazard criterion into certain legislations, it turned out that the test methods in regulatory use do not do a particularly good job detecting endocrine disruption. As a response, the EU and other players in Europe are now investing funds in the development and regulatory uptake of new EDC testing methods.

Actually, of the over 350,000 chemicals in use, only a very small fraction have been tested for human toxicity and ecotoxicity. Hazard assessment is performed either by regulatory bodies

or the producers of the respective chemicals in so-called test guideline studies. Test methods accepted for regulatory decisions are based on traditional toxicological concepts and mainly based on animal experimentation, which makes them time-consuming, expensive and ethically problematic. For this reason, extensive testing is avoided. New methods based on recent scientific insights and state-of-the-art technologies, often without the use of experimental animals, are being developed and used in academic settings. However, their acceptance for regulatory decision-making is extremely slow and takes years if not decades. This must change if we want to accurately assess the hazard not only of currently used chemicals, but in particular of all the new chemicals that are being produced and released at a rapid pace. Key here is that regulators build trust in new methodologies and results from non-regulatory settings, e.g., from academic laboratories. This has already happened in certain cases, for example in The European Food Safety Authority's recent decision to lower the tolerable daily intake (TDI) of the industrial chemical bisphenol A (BPA) by a factor of 20,000, based on a systematic review of the existing evidence, including findings from academic studies.[10]

Hazard assessment is one important step in protecting humans and the environment from dangerous chemicals. Another is exposure assessment, i.e., measuring or predicting at what levels an individual or populations are exposed. Monitoring of chemicals in the environment and human samples plays an important role in estimating exposures, in tracking chemical pollution over time, in detecting trends and changes, and in providing early warnings of potential hazards. Monitoring programmes exist for both humans and the environment; however, they cover only a small fraction of the thousands of chemicals in use. Thus, emerging chemicals and their potential health impacts are overlooked. One way to promote proactivity is to make declaration of chemical content mandatory in all materials, products and goods. Such knowledge is a cornerstone for exposure assessments – assessments currently promoted by novel analytical methods comprised in the term "Exposome", including targeted, untargeted and a set of different OMICS methodologies.[11] The exposome encompasses an individual's lifetime of environmental exposures (chemical, physical, socioeconomic and lifestyle) over the lifetime and how these culminate to determine health or disease. The exposome approach requires close collaborative efforts and infrastructural investments. Furthermore, important questions concern not only technological advances, but also how monitoring can be efficiently organized regionally and globally, and who is responsible for its costs.

The issues outlined here are multifaceted and require the engagement and interaction of all players, from regulators to policymakers and civil society, from industry to the scientific community. Scientific efforts to develop new solutions have to be interdisciplinary, integrating environmental toxicology, chemistry, and epidemiology with engineering and social sciences. But while such interactive and interdisciplinary processes take time, action is needed urgently. The Uppsala Health Summit will provide a stimulating and inclusive environment for addressing these issues from a One Health perspective, discussing solutions on different timescales, from immediate actions to longer-term investments. We trust that the summit will result not only in raised awareness about the issues, but also in concrete recommendations for management practices, policy instruments, and ongoing political processes that are required on the path towards zero pollution and a toxic-free environment.

PHOTO BY GETTY IMAGES

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Workshop A

Towards an Intergovernmental Panel on Chemical Pollution

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Chemical pollution from manmade or refined chemical substances, mixtures and undesired by-products as well as from their abiotic and metabolic transformation products is one of the major recognized societal challenges related directly or indirectly to the UN Sustainability Development Goals (UNEP 2019a, UNEP 2019b). This also applies to particulates, polymers and debris from various anthropogenic materials, i.e., waste. Management of selected chemical pollutants is addressed through global UN Conventions (so-called "multilateral environmental agreements" such as the Stockholm, Basel, Rotterdam and Minamata Conventions), but many more chemicals and mixtures need to be soundly managed, and science-based advice on options for such sound management of chemicals and waste should be made available to stakeholders and governments. In the areas of biodiversity loss or climate change adaptations, IPBES, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, or IPCC, the Intergovernmental Panel on Climate Change, are intergovernmental panels that provide such advice.

Resolution 5/8, adopted at UNEA-5.2 in March 2022, provides a very good "backbone" for establishing the Science-Policy Panel (SPP) on chemicals, waste and pollution prevention (UNEA 2022). Now, during the process leading to establishment of the panel, it is important to ensure that procedures and operating principles set for the new panel will allow the panel to provide sound and unbiased advice and will not delay decision-making processes.

It will be useful to discuss more broadly which principles should be attended to and which mechanisms and procedures should be carried forward given the experience available from the work of IPCC and IPBES, including mobilization of scientific expertise, sufficient inclusion of academia, and identifying and handling stakeholders' conflicts of interest (COIs).

PHOTO BY IISD/ENB | NATALIA MROZ

Aims of the workshop

The aims of the present workshop include:

1. To provide input and recommendations in the process of SPP development, i.e., to the regional consultations that will be held during October or early November 2023 in some regions. Accordingly, this workshop document could be used there or sent out to Open-Ended Working Group (OEWG) bureau members for their attention.
2. To provide recommendations for OEWG-2 in Jordan in December 2023. Here, we may add that our intention is to organize a side event meeting to OEWG and/or to deliver an INF document to OEWG-2.
3. To discuss several operational principles/ criteria so that the future SPP can engage relevant scientific expertise on chemical pollution and waste without COIs.
4. To raise awareness concerning how the scientific community can meaningfully engage in OEWG's negotiation process.

Topics for discussion

1. What are the issues at stake for optimization of SPP (e.g., prioritization of topics, format of the output)?
2. Who can take part in the panel once established and what product(s) does the SPP deliver?
3. How can we engage the most relevant experts to join the panel, particularly scientists without COIs, to ensure the best scientific advice possible?
4. Are we currently experiencing any barriers related to dissemination of scientific information in the field of chemicals, waste and pollution?

Broader background in the field of chemicals, waste and pollution and the current state of SPP negotiations

Science is instrumental in generating new knowledge as well as in providing evidence for the awareness-raising and decision-making process that underlines choices for policy and management options, leading to stronger protection of the environment and human health from hazardous chemical pollution. The role of science has been clear ever since the first observations of mercury effects known as the Minamata catastrophe more than 60 years ago and following additional observations around the globe. Other serious effects of chemicals on environment and health are related to pesticides (e.g., DDT,

"drins", hexachlorocyclohexanes) that emerged in the 1960s, followed by a wide variety of organic chemical products such as PCBs, dioxins, halogenated flame retardants and per- and polyfluorinated chemicals (PFAS) (UNEP 2012, Chapter 6).

Recent findings/reports generated by UNEP state that chemical pollution is as serious as climate change and biodiversity loss (UNEP, 2021) and that the efforts of all stakeholders must be mobilized and strengthened to combat this triple planetary crisis (UNEP 2019a, UNEP 2019b).

At the global level, the United Nations Environment Assembly, at its resumed fifth session (UNEA-5.2) in March 2022, adopted its resolution 5/8 on an SPP, contributing further to the sound management of chemicals and waste and to preventing pollution. Since October 2022, negotiations have been ongoing within an ad hoc OEWG to prepare proposals for the SPP, with the ambition of completing the necessary arrangements by the end of 2024. The new SPP is to be established in 2025.

The first OEWG session was held in two parts. The first part (OEWG 1.1) took place in Nairobi in a hybrid format, with online participation, on 6 October 2022, and the resumed first session (OEWG 1.2) in Bangkok from 30 January until 3 February 2023.

The first session focused on the scope and functions of the SPP. Currently, preparations are ongoing for the second session, which will focus on operating principles, institutional and governance design of the panel and will also look closely into relationships of the panel with relevant key stakeholders, including governmental and non-governmental organizations (NGOs) and procedures of the involvement of experts. Finally, procedures for adopting the policy outcomes of the panel will also be discussed.

Activities of the scientific community

It should be noted that the scientific community also organizes itself. One step in addressing chemical pollution using science-based advice was already taken more than 15 years ago, when the International Panel on Chemical Pollution (IPCP) was established (Scheringer et al. 2006). "*IPCP aims to develop a scientifically sound and balanced view of major issues of chemical pollution and evaluate different options for chemicals management. Based on its scientific expertise, the IPCP supports political processes at the national and international level*" (bylaws of the IPCP, www.ipcp.ch). However, the IPCP is an association of academic scientists, not an intergovernmental organization, and legally it participates in the current process as an NGO like many others. The task of addressing and overcoming chemical pollution is an issue for the global community at the intergovernmental level.

The scientific community can participate in the SPP negotiation process in different ways (Ågerstrand et al. 2023, Carney Almroth et al. 2023). One is through the national delegation of a member state. However, this option is available only to a small number of scientists from each country. It requires that scientists be in relatively close contact with their governments and be nominated as members of the delegation. A second way is through NGOs that are accredited as observers with UNEP or admitted as observers with any of the Basel, Rotterdam, Stockholm or Minamata Conventions. All of these NGOs can nominate a delegation for the OEWG meetings.

Challenges that OEWG2 and OEWG3 need to tackle

The second meeting, OEWG2 in December 2023, will look at the operating principles, participation as well as the format of outputs.

One crucial aspect of the establishment and work of the SPP is the way in which COIs are handled. This includes formal COI rules and policies to be defined and adopted for the panel, but also an appropriate way of reacting to and avoiding COIs (an aspect of governance) in both the establishment and operation of the panel. COIs are of particular importance in the context of a panel on chemicals, waste and pollution prevention, because the chemical industry is an important and influential stakeholder in the area to be covered by the panel. It has been documented extensively and with undeniable evidence that COIs have strongly affected the way in which the chemical industry has operated over the past decades (Michaels 2008, Oreskes and Conway 2010, Goldberg and

Vandenberg 2019, Mie and Rudén 2023, Gaber et al. 2023).

In light of this evidence and experience, it will be of particular importance to define the way in which the chemical industry may contribute to the work of the SPP. This concerns the role of chemical industry representatives as well as representatives of industry associations that have not-for-profit status and scientists working for the chemical industry or chemical industry associations, but who are affiliated with formally separate organizations such as think tanks, consultancy firms or even academic institutions. There must be mechanisms and procedures put in place that will make it possible to identify the funding sources and competing interests of all these representatives. Another important area is the way in which the panel may use relevant data provided by the chemical industry. Data on chemical physicochemical properties, hazards, uses and emissions, as well as impacts of chemicals will be highly relevant to the work of the panel. In some jurisdictions, e.g., the European Union, chemicals regulation requires the chemical industry to provide these data. In other parts of the world, the demand for chemical-related data is smaller. There is an ongoing debate concerning the availability and quality of industry-generated data (Stieger et al. 2014, Springer et al. 2015, Zainzinger 2020) and to what extent these data should be requested by the panel, in addition to data that are publicly available. It will be important to provide the OEWG, for its upcoming second and third meetings, with sufficient documentation and recommendations regarding the use of industry data.

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Workshop B

Testing Our Way to a Safe Environment

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Introduction

There are about 140,000 individual synthetic chemicals in commerce worldwide today (Bergman et al. 2013). Many of these chemicals have not been tested for safety, and those that have been evaluated were tested by a system that is known to be both slow, expensive and is insensitive to certain kinds of toxicity (Kortenkamp et al. 2011). To move toward a sustainable, toxic-free future that is nonetheless sensitive to market concerns, testing methods and strategies must adapt to accurately identify hazardous chemicals and the risk they pose to human health and the environment more quickly and more efficiently (Council 2007).

Aim of the workshop

The perfect toxicity test is not available, nor will it be in the near future. However, we believe that we have a potential to develop the toxicity testing strategies used today in ways that could improve human health risk assessment. To contribute to bridging the challenges of today, the current workshop aims to;

- Categorize the different perspectives on strategies to improve chemical testing as it relates to the goal of a toxic-free future.
- Identify obstacles to achieving each of these strategies.

PHOTO BY CHAT GPT

Chemical Testing Informs Risk Assessment

The basis of chemical risk assessments includes the scientific data relevant to the assessment and the general principles and assumptions used to interpret the data and overcome data gaps (Ruden 2006). Philosophically, testing chemicals for safety is different from testing chemicals for toxicity. That is, should we assume chemicals are safe until proven unsafe? Or should we assume chemicals are toxic until proven nontoxic? The fundamental principle of regulatory toxicology is that "all things are poison, and nothing is without poison" (McCarty et al. 2020), necessitating the assumption that all chemicals are "poison" (i.e., "toxic") and that it is the dose that makes the poison. Thus, chemical risk assessment, the process of identifying the risk of a chemical to human health and/or the environment, is designed to identify the exposure level above which adverse effects are causally related (Ruden 2006).

However, the risk assessment procedure leading to chemical licensure or restriction consists of 1) hazard identification, 2) hazard characterization (dose-response assessment), 3) exposure assessment, and 4) risk characterization. Each of these steps is quite complex. For example, what is the hazard? Is it a carcinogen, a reproductive toxicant, or a developmental neurotoxicant? Is it an endocrine disruptor, a metabolic disruptor, or a liver toxicant? These are just a few of the categories of hazard, and each category is quite complex because there are many types of hazards within each category, such as the type of cancer, reproductive or neurodevelopmental abnormality, etc.

It is also challenging to link the type of hazard to the types of measurements in a toxicological study. This can be specifically true when addressing complex traits such as brain function or reproduction. While experimental animal studies can provide mechanistic knowledge and causal links between exposure and outcomes, the extrapolation to humans is not always straightforward. Likewise, relevant toxicity endpoints might not cover more subtle or complex traits. For example, to what extent does brain weight indicate a developmental neurotoxicological hazard? Clearly, there are brain-based disorders that are not identified by changes in brain weight, such as attentional or cognitive deficits, autistic spectrum disorders, or many other brain-based disorders. But what endpoints in a toxicological test would be a clear indication of this kind of hazard? It would be simpler

if there were a single measure of "toxicity," but there isn't and there can't be as toxicity can range from endpoints observed at the point of exposure all the way to generations later. So, what assumptions do we make surrounding the "coverage" of the toxicological data employed for risk assessment? How can we improve the speed and efficacy of chemical testing that informs policy decisions that ultimately determine, in part, what chemicals the human population are chronically exposed to?

Challenges to Solutions

The solution will not be found solely in the kinds of assays that are required for regulators to interpret toxicity of single chemicals, though this is certainly important. Methods to identify and characterize the risk of chemical mixtures will also be required. An important recent example is that of Sprong et al. (Sprong et al. 2023), who performed a mixture risk assessment of dietary exposure to food contaminants lead, methylmercury, inorganic arsenic, fluoride, non-dioxin-like polychlorinated PCBs and polybrominated diphenyl ethers, finding that human populations in all 9 of the European countries studied exceeded combined tolerable levels at median exposure levels in relation to IQ loss. Thus, the "safe level" of these chemicals based on their individual toxicity data failed to protect the human population. We should not underestimate the human health (and economic) impacts of these findings and should strive to be more effective.

There is also a global desire to decrease the number of animals used in toxicity studies by developing biochemical, cell-based or computer-based assays to inform risk assessment. These so-called "New Approach Methods (NAMs)" are being explored on a large scale. The issue of validation of individual assays is important and will require time for development, but the issue of interpretation of the individual assay in the context of risk assessment is also important. The goal of replacing animals used in toxicological experiments with these NAMs will be an important debate.

There are other, non-chemical approaches to reducing toxicity. A good example is that of chemical flame retardants in household goods. Although intended to mitigate the risk of fire, these chemical additives to household goods were not ultimately effective (Page et al. 2023). Thus, developing a rational approach to regulations that encourage non-chemical methods to reduce chemical exposures will be important. However, this is beyond the scope of the current discussion.

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Workshop C

The Health and Environmental Challenges of Recycling Chemicals in the Sustainable Management of Plastics

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Introduction

The million tonnes of plastic litter that end up in the oceans every year are one, but not the sole, impact of past and present plastic production, consumption, and disposal. Recycling of plastic materials is suggested to be a solution to the environmental problem, but is also required in the transition to a circular economy. The new plastics economy, in which the design and production of plastics fully support recycling, requires more sustainable materials to be developed and promoted. Transferring from a linear to a circular value chain demands transformative changes. It has been suggested that concerted efforts need to be directed towards the large variety of chemicals found in plastic products, used as building blocks, added to provide desired properties, or present as unintentional by-products. Several thousand different chemicals are associated with plastics, and thousands have been identified as a potential concern for human health and the environment. Identified critical aspects of recycling plastics are lack of information and traceability of chemical contents as well as limited hazard data on chemicals in use. It is, therefore, very important that a common vision for recycling of plastics be established among all key players in the value chain and that critical factors in the transformation process be identified, to avoid regrettable lock-in effects in terms of recirculation of chemicals, thus creating new problems when solving the original one. Plastic products are complex, comprising thousands of different types that contain numerous chemical additives. Circularity objectives focus on cost, use of resources, and carbon footprint. However, understanding and managing the chemical contents of recycled raw materials are critical to the health-related safety of recycled plastic materials.

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Aims of the Workshop

This workshop will discuss the roadmap for future management of plastics and recycling of plastics, from a human and environmental health perspective, focusing on issues related to chemicals in plastics. Chemicals related to plastics and recycled plastics are numerous and to some extent unknown. The workshop will focus in part on current knowledge on the identity and effects of plastic-related chemicals, and methodologies used to assess plastic-related chemicals, but also discuss the main uncertainties regarding plastic-related chemicals and their fate in recycling. What management is needed for the safe recycling of plastics, and how can hazardous chemicals be removed from plastics and recycled plastics to protect humans and the environment?

Background

The challenges with chemicals in plastics

Chemicals are vital to our society, to human wellbeing, economic growth, and innovations such as the green energy transition. Almost no products are produced without industrial chemicals. However, many chemicals also pose threats to human health and the environment. Plastic products are complex, comprising thousands of different chemicals, including building blocks, unintentionally added reaction by-products, and intentionally added additives such as plasticizers, stabilizers, biocides, flame retardants, accelerators, colorants, etc. A survey of plastic packaging materials indicated that over 4000 chemicals were associated with the plastic materials. Of these, 68 rank high for environmental hazards, 63 rank high for human health hazards and 34 are endocrine-disrupting chemicals. Plastic products are tailor-made to the intended application. Electronic parts, plastic toys, food contact materials, or medical devices require different properties compared to packaging materials and, thus, contain different chemical additives. Plastic materials made from recycled plastic raw materials may therefore contain a complex mix of both intentionally and unintentionally added chemicals. This unknown composition of chemicals is a goal conflict in the circular process and constitutes a monumental challenge for sustainable management of plastics. In a transformative change of plastic management, the issue of the chemical content of plastic materials needs to be addressed.

Chemicals of potential concern for humans and the environment are typically identified by fulfilling one or several hazard criteria. For example, REACH defines criteria for substances of very high concern, and substances that are persistent, bioaccumulative, and toxic. However, many of the chemicals in use today have not been fully evaluated, and for some there are research data suggesting a potential hazard.

Identification and subsequent legislation of hazardous chemicals are often preceded by decades of investigations, during which time the investigated chemical has been produced, used and possibly also re-used through recycling.

As our knowledge about substances of concern improves, the problem arises of how to deal with newly regulated substances that were legitimately added to older products. Actions promoting the circular management of plastics should therefore be directed not only at managing risks associated with the current use of known chemicals, but also at addressing the fate of historical use of chemicals and possible future discoveries. Legacy substances in recycled raw materials are an inherent problem caused by the time difference between restrictions on substances entering into force and the time it takes for products containing such substances to reach the end of their service life and become a recycled raw material. Information on chemical content is not available when chemicals are incorporated into a plastic product, even though the product might later transition to a raw material for new products. The increasing number of chemicals used in manufacturing, and the complexity of chemical mixtures in products, such as plastics, might hamper re-use and instead reinforce a linear process with an end-of-life termination. The best way to prevent substances of concern in recycled products is by avoiding using them in products in the first place.

The composition of plastic waste streams is not fully predictable, nor is it constant. This challenges future use of recycled plastics in applications with high demands regarding traceability of the chemical content, such as food packaging material or medical applications. In such cases, decontamination technology or extended analytical and quality control approaches may be the only feasible way to guarantee that the recycled materials are safe for any given specific use. Controls and safety restrictions for recycled plastics in food contact materials already exist, as information on chemical contents, including contamination of the recycled raw material, is lacking. This raises the question of whether recycled materials can only be used for applications that are not sensitive to human health. This would require enhanced supply chain collaborations and a division into sectorial platforms, ensuring that, for example, electronics are not recycled into children's toys.

The demand for and production of plastics are predicted to double in the next 20 years (World Economic Forum, 2016). Recycling is one action to reduce the use of fossil materials, using biobased raw materials is another. Biobased plastics are often perceived as a more environmentally friendly option than conventional plastics, which are fossil based. However, the actual impact of biobased plastics on the environment and humans is not necessarily better, and chemical additives are still used regardless of the starting material. Some studies have even shown higher ecotoxicological effects from biobased microplastic particles compared to conventional plastics.

The problems of assessing chemical hazards

Traditional assessment of chemicals in plastics has been conducted using a targeted approach, one chemical at a time. Given the large universe of chemicals associated with plastics (over 10,000), this is not practically feasible, and there is also a potential risk of missing unexpected chemicals that are not on the list. Rapid and cost-efficient analytical methods are required – methods that can screen for hazardous chemicals in a nontargeted way that allows for detection of unexpected or unknown chemicals relevant to human health. Such methods, however, are not routinely implemented at commercial laboratories. Effect-based monitoring is an alternative method that uses sensitive bioassays with high predictive power for hazards to human and environmental health. These assays capture the effect signal from the complex mixture of chemicals using selected endpoints and return the effect signal of the entire group of chemicals. Considering the large number of chemicals in use, complementing target analysis with group-based methodologies would seem to be a viable option for moving forward towards safer products. One important question remains: What are the actions taken when a suspected hazardous chemical is detected that lacks limit value or has limited hazard data? Addressing the presence of hazardous chemicals in recycled materials through comparison with corresponding virgin material is one option that may not necessarily result in safer products.

PHOTO BY GETTY IMAGES

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Workshop D

Future Monitoring of Chemical Exposure and Effects in Humans, Wildlife and the Environment

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Introduction

Chemical pollutants can have a range of adverse effects on human and animal health, including cancer, reproductive and developmental problems, and on the environment through ecosystem disruption. By monitoring the levels of chemicals in biotic and abiotic media, we can identify the presence of harmful pollutants and track changes in their concentrations over time. Monitoring data can be used to support risk assessment and risk management, such as evaluating the potential health risks associated with exposure to a particular chemical or identifying populations that may be at higher risk of exposure.

Monitoring of chemical pollution in the environment (including animals) and in humans is often separated, with little or no collaboration across scientific boarders (Figure 1). Changing this perspective can result in opportunities for knowledge exchange, shared resources and joint efforts. By working together across different sectors and disciplines, we can better understand the impacts of chemicals on health and ecosystems and develop strategies to protect human, animal and environmental health. Using the One Health concept can help us take a more integrated and holistic approach. This can, in turn, inform policy and management decisions aimed at reducing exposure to contaminants through prevention and early interventions.

However, working together requires facilitation of communication between different areas. One way to increase communication and create bridges between the various monitoring activities is to fill relevant knowledge gaps currently obstructing an interactive approach. This could be by linking human exposure to environmental exposure, comparing organ levels between animals and humans, or finding relevant biomarkers and thresholds.

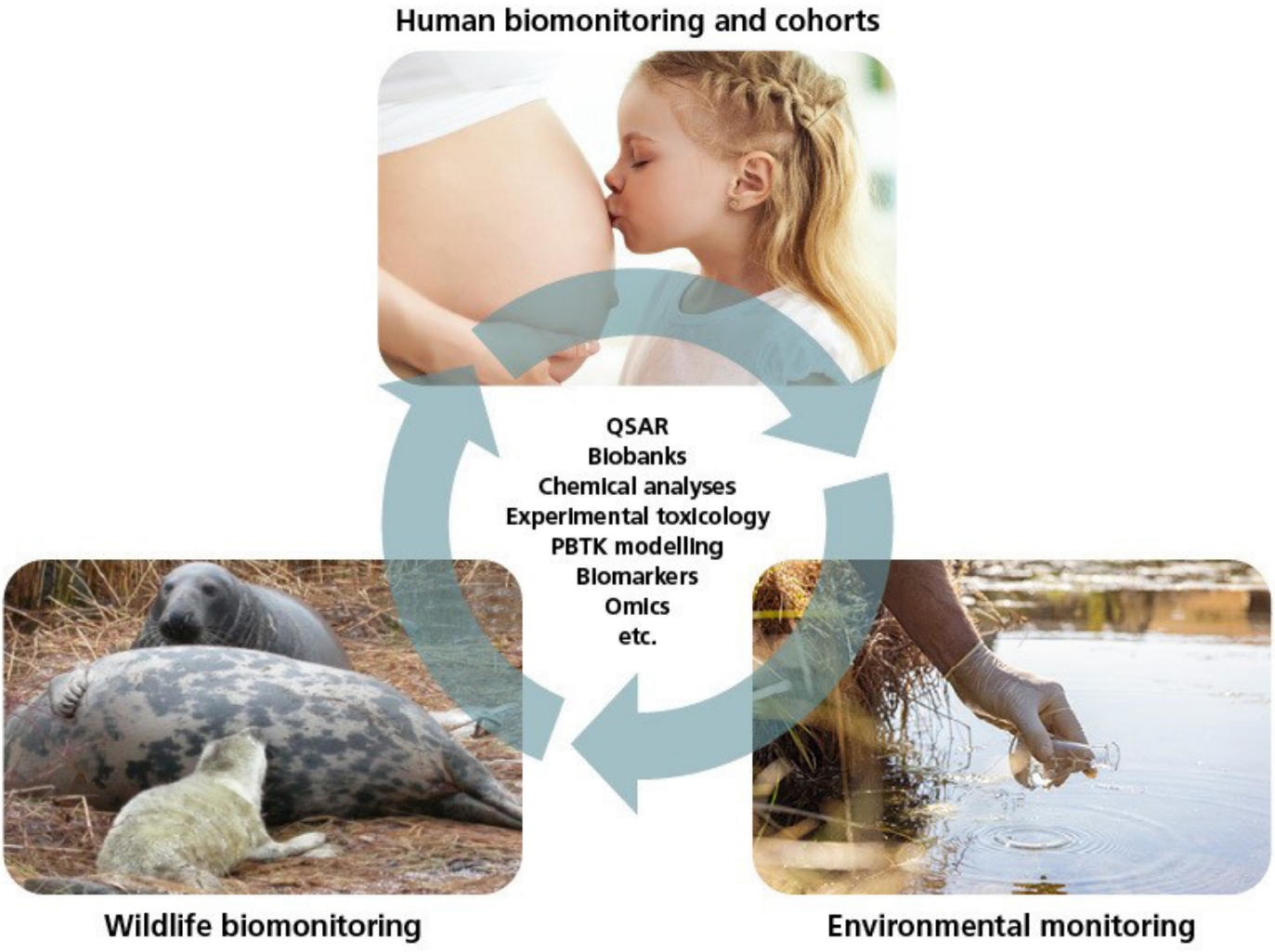

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Figure 1. Monitoring chemicals in a One Health approach – i.e., interlinking activities and methods between the different research areas – needs to be developed in a direction that ensures collaboration, communication and coordination.

Aim of the Workshop

This workshop will bring together participants with expertise from different fields of monitoring of dangerous chemicals to discuss and identify common challenges, share perspectives and facilitate collaborations beyond the workshop.

The aim is to provide a forum for participants to discuss new ideas and explore approaches that can improve the monitoring of chemicals as well as identify possible solutions for building bridges and integrating efforts for a holistic One Health approach.

Background

Chemical monitoring

Monitoring programs are designed to track chemical pollution over time, detect trends and changes and provide early warnings of potential hazards. This is an essential tool for understanding the state of the environment and identifying potential risks and threats to human and animal health. Monitoring is most often based on recurring and systematic sample collections and analyses. The data collected through these programs are used to inform environmental policy and management decisions, as well as to track progress towards national and international environmental objectives.

In a national monitoring setting, sampling is usually the first step, covering various *environmental media* such as air, water, and soil, but also biota such as tissues from *humans* and *wildlife* in the form of blood, urine, feathers, milk, eggs and/or organs. Environmental specimen banks and biobanks play a crucial role in preserving and securing samples for the future that can be used for assessment of long-term trends of regulated and emerging chemicals as well as bioaccumulation and biomagnification of chemicals in food webs. The stored samples can also be used to explore associations between chemical exposure and health outcomes and contribute to early warning systems in the event of environmental incidents or disasters by comparing current samples with archived samples. In this context, some organisms are considered sentinels or indicator species because they are particularly sensitive to pollutants in one way or another.

Monitoring efforts can focus on effects or exposure or be combined in, for example, effects-driven analysis or epidemiological studies

on humans and wildlife. Cohort studies in humans provide an opportunity to examine associations between environmental exposures and health outcomes. The use of biomarkers for exposure and effects can also be very valuable. Sample analysis for the presence and concentration of chemicals traditionally includes targeted analysis on pooled or individual samples, although more advanced analytical methods can also be used. Chemical (and other) data collected through the monitoring program must undergo quality control and validation processes to ensure accuracy, reliability, and comparability before they are made freely available in open databases.

Future challenges

There are many challenges for future monitoring of exposure to and adverse effects of chemicals. For example, it can be difficult to keep up with the identification and monitoring of emerging contaminants because new chemicals are being rapidly developed and used in society. Our knowledge about emerging chemicals is often lacking, with limited information available on these chemicals' properties, behavior and potential risks. These substances can pose significant environmental and health risks, but they are often not included in existing monitoring. For monitoring to be effective, it is furthermore important to have the appropriate tissues and analytic methods available. Sensitive and specialized analytical methods may be required, but these may also be costly and time-consuming to develop and use.

Environmental specimen banks and biobanks strive to preserve samples for future use. It is crucial to ensure the quality and integrity of the samples during long-term storage. Sampling, handling and storage are mostly standardized to ensure comparisons over time. In this sense, monitoring differs from research projects, which are limited in time and generate data that may be difficult to replicate. However, the sampling methods used within monitoring today may influence the usefulness of the samples in the future, as they can affect the type of analyses that can be performed. New sampling and storage protocols may be needed to meet the requirements of new analytical methods, such as a variety of -omics disciplines.

Another challenge is the volume of data generated by monitoring programs. For example, while non-target analysis can be a powerful tool in monitoring, it results in large datasets. Developing robust tools for managing and analyzing huge and diverse datasets is likely to be a significant challenge in the future.

There are of course many more examples of challenges and problems. The way we decide to solve them can affect our ability to effectively address complex health challenges, which in the worst case can lead to increased health risks as well as environmental risks. It is therefore important to embrace a comprehensive, integrated approach to ensure the health and well-being of humans, animals and the environment.

One Health in chemical monitoring

The One Health concept is an approach that recognizes the interconnection between human health, animal health and environmental health. The concept emphasizes the importance of collaboration, communication and coordination between different fields of expertise, such as human health, veterinary medicine, environmental science, epidemiology, computer science and toxicology to promote the health and well-being of all living beings.

Chemical exposure can impact the structure and functioning of ecosystems by affecting the health of individuals and populations. A disturbed ecosystem can lead to air and water quality loss, diminished ecosystem services and increased risk of diseases, such as vector-borne diseases or abnormal parasite load. Consequently, the functioning of ecosystems is intimately linked to human and animal health.

Integrating toxicological investigations on humans and wildlife can provide a more complete understanding of the potential risks and identify links between chemical exposures and health outcomes. Field studies that focus on the toxic

effects of chemicals in natural settings, such as in wildlife populations, can provide insights into the potential ecological impacts of chemical exposure as well as comparative aspects with human epidemiology. This can facilitate the identification of priority chemicals and support risk assessment and management, but further collaborative initiatives and method development are required (Figure 1). Methods for comparative toxicology can include *in vitro* testing using cells and tissues to study the toxic effects of chemicals, providing knowledge on the mechanisms of toxicity without the use of animal testing. Another example is computational modeling, such as physiologically based toxicokinetic modeling (PBTK) or quantitative structure–activity relationship modeling (QSAR), which can be used to predict the toxicity of chemicals based on their chemical properties and known toxic effects in other species. These methods can help to identify potentially hazardous chemicals and prioritize them for further testing.

Workshop discussions

In this workshop, the focus will be on facilitating interaction and improving communication between monitoring activities. Examples are shown in Figure 1, which can be further updated.

- What are the most pressing challenges within environmental and human monitoring today and in the future?
- How do we create monitoring and research frameworks for wildlife and human exposure that will ensure that we can track and respond to emerging chemicals?
- What methods should we use to bridge the gap between our understanding of exposure and effects in humans compared to wildlife and the environment?
- How can research help in improving environmental and human monitoring from a One Health perspective, and how can researchers make use of the collections and data generated within monitoring?

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Workshop E

Conflicting Objectives

Using Effective Drugs Without Polluting our Environment

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Aim of the workshop

The aim of this workshop is to move towards a common understanding of effective ways to tackle pharmaceutical pollution. The outcome will form the basis for a set of policy recommendations, based on both present strategies and new ideas, that can guide intervention and risk mitigation on multiple levels and at different phases in the life cycle of pharmaceuticals.

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Background

Chemicals are part of our everyday life and have many beneficial effects in our society. However, harmful chemicals need to be used with caution, especially when such chemicals are persistent and will remain in our environment with the potential to exert harmful effects om humans and other organisms.

Pharmaceuticals: a special case

Pharmaceuticals, used to prevent and cure disease, can be considered a special case of pollutants. They are designed to interact with physiological processes, often by direct and strong interactions with receptors or enzymes. They are also in many cases stable, the aim being to be able to reach their target organs and exert the intended effects. In general, pharmaceuticals have an inherent ability to cause unwanted effects when organisms are inadvertently exposed.

Environmental exposure

Hundreds of different active pharmaceutical ingredients have been found in treated sewage water, surface water, drinking water, groundwater, sediment, soil, biota, etc. Because many of them are designed to resist degradation, their persistence causes unwanted extended exposure in many environmental compartments. For a review of exposure in aquatic fauna, see *Miller et al. (2018).* Pathways for pollution include household and industrial wastewater treatment systems, aquaculture facilities, manure application,

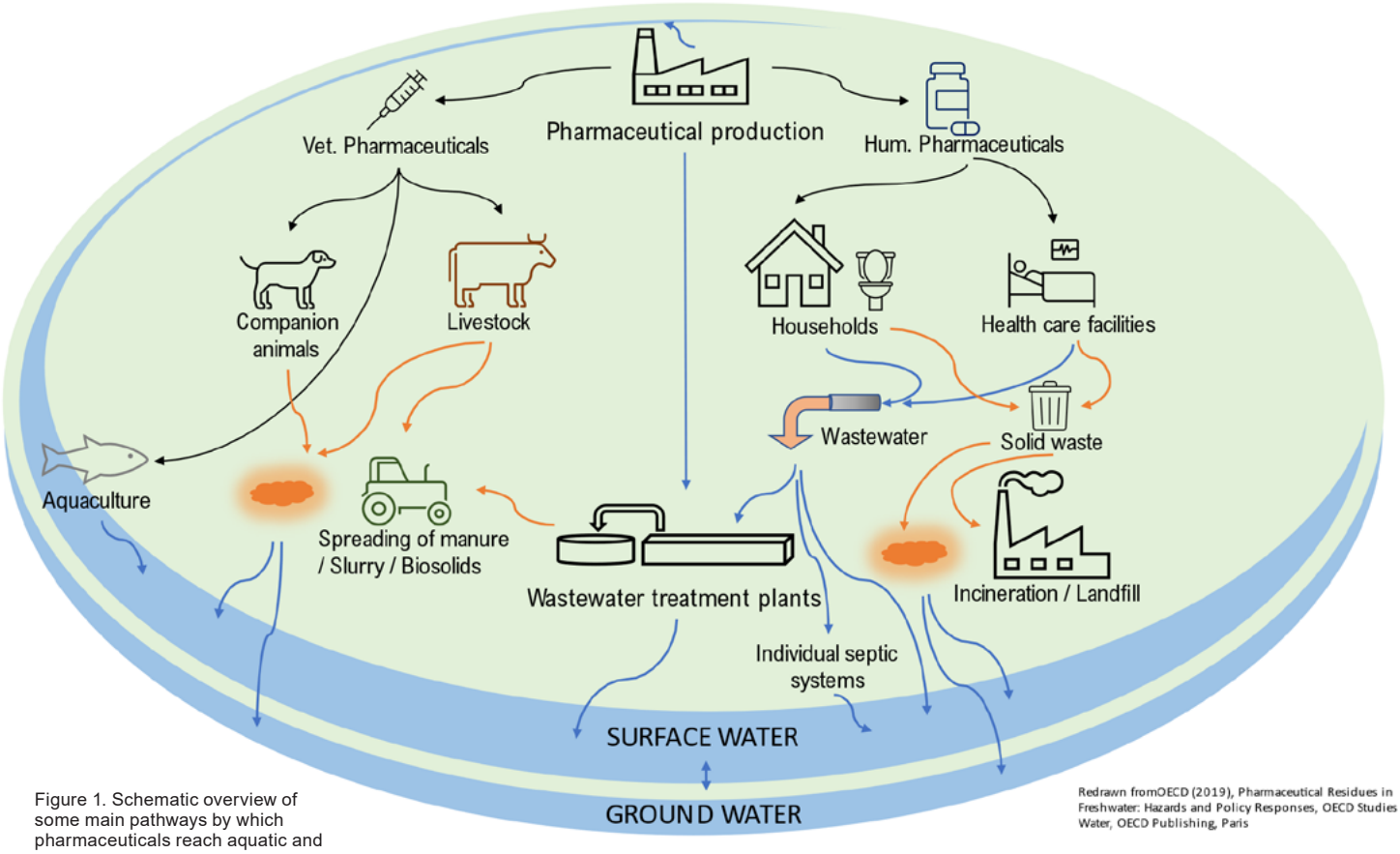

Figure 1. Schematic overview of some main pathways by which pharmaceuticals reach aquatic and terrestrial ecosystems.

Redrawn fromOECD (2019), Pharmaceutical Residues in Freshwater: Hazards and Policy Responses, OECD Studies on Water, OECD Publishing, Paris

landfill and incineration, as schematically illustrated in Figure 1. The contribution of different sources varies across geographical locations. While it is generally thought that most emissions can be attributed to the excretion of used pharmaceuticals, production sites have been shown to contribute largely to local emissions. The globalized production chains where API and pharmaceutical products are in many cases produced in LMIC countries suffer from lack of transparency, which is why it is difficult to analyse and target these emissions where it would be most efficient. Improved wastewater management has the potential to markedly reduce emissions from both production and use. Currently, however, advanced treatment of wastewater from households and healthcare is very limited even in countries where the economic conditions could favour such solutions.

Effects of pharmaceutical pollution

Exposure to pharmaceuticals in the environment has been linked to risks for impaired reproduction in fish and frogs, renal failure in vultures as well as altered growth and reproduction in aquatic invertebrates. Furthermore, the presence of antibiotics in the environment can lead to new forms of antimicrobial resistance and the spread of already resistant strains. Antimicrobial resistance is considered one of the largest threats to health, and besides actions taken to reduced resistance development in humans and animals under treatment, the role of environmental pollution in AMR is increasingly being observed.

Policy and legislation

Access to safe and efficient medicines is vital to human and animal health, but it is also clear that actions must be taken to protect our environment and the other organisms we share it with. To this end, several policies and regulations concerning chemical pollution have been introduced over the past decades. Increasingly, development of these policies and regulations is also considering pharmaceuticals and personal care products. Still, it should be noted that, for example in the EU, pharmaceuticals as products are exempt from most provisions under the EU´s general chemicals legislation. In 2019, the European Strategic Approach to Pharmaceuticals in the Environment was launched with the aim to counteract the negative effects of pharmaceuticals on the environment, covering their whole life cycle from design and production through use and disposal.

Miettinen and Khan (2021) published a comprehensive overview of international efforts targeting the regulation of pharmaceuticals in the environment. Their analysis concludes that pharmaceutical pollutants are chemicals of concern that fall outside the scope of international treaties. Furthermore, *Desai et al. (2022)* compared environmental policies to reduce pharmaceutical

pollution in the US, EU, and Canada. One of their main conclusions was that current regulations and measures are falling short in their aim to reduce pharmaceutical contaminants in the environment. One main reason they put forward was lack of reliable and relevant prospective risk assessment procedures as well as failure to set acceptable limits for APIs in the environment.

How will we contribute with this workshop?

At the workshop, by starting off with the pathways of pollution (Figure 1), we will map actions and actors. We will also put our efforts into thinking "outside the box" by considering the whole system, including producers, users, payers, legislators, etc., in the hope of designing new solutions. Based on this, we will discuss responsibilities and policy needed to intensify the work with protecting the environment while providing safe and efficient medicines, affordable also in the less affluent parts of the world.

Some questions we hope will be discussed at the workshop are:

- Where do the responsibilities lie for addressing pharmaceutical pollution?
- How can we address the fact that the life cycle of pharmaceuticals – from API precursor production, via use, to waste – is globalized and that environmental and pharmaceutical legislations are not harmonized?
- In a more long-term perspective, which actions can prevent or reduce the problem of pharmaceutical pollution, perhaps also at a lower cost?
- Can initial substantial investments in short-term solutions gradually be decreased and funds reallocated to mid- and long-term solutions?
- What are the measures needed to form a set of policies that take a systems perspective on the problem?

Which actors do we expect to take part?

This workshop invites all stakeholders and actors from the private, public and non-profit sectors with an interest in working towards a strategy for safeguarding the environment while maintaining access to safe and effective treatments for humans and animals. We especially encourage the participation of representatives from health and environmental ministries, environmental protection agencies, the pharmaceutical industry, healthcare providers, academia and NGOs dealing with Pharmaceuticals in the Environment or with chemical pollution in the broader sense.

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Workshop F

Water Quality in One Health

Managing Chemical Risks

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Introduction

Clean water is a prerequisite for healthy ecosystems and one of the United Nations' Sustainable Development Goals (SDGs; #6). As reflected through several EU Water Directives recently being implemented or reviewed (European Comission, 2020; 2022a; b), the pressure on ensuring good water quality for different types of water resources will be increasing at national and European levels. In this light, addressing contaminants of emerging concern (CECs) in the water cycle is one of the focal points. For example, the new European Drinking Water Directive has recently been revised to protect human health from harmful effects of all types of drinking water pollutants by ensuring that it is healthy and clean from source to tap as well as to improve access to drinking water for everyone in the EU. For municipal wastewater, a quaternary treatment step at the treatment plants is proposed by EU with the aim of removing indicator organic pollutants by at least 80% and also implementing the extended producer responsibility. As pharmaceuticals and the cosmetics sectors are jointly responsible for 92% of the toxic load in wastewaters, companies putting these chemicals on the market will be asked to be financially responsible for the costs of the quaternary treatment.

Pollution of water bodies involves irreversible processes. Drinking water is our main food, with an adequate intake comprising 2-2.5 L per adult and day. Therefore, its source waters must be protected from hazardous compounds. Because drinking water consumption is continuous, even trace amounts of chemicals may result in significant exposure, which might cause human harm, such as gene mutations, cancer, neurotoxicological effects, metabolic disorders, and impairment of the immune and reproductive functions. Better quality of treated drinking water, wastewater or reclaimed water is needed to meet the required goal of clean water as well as to facilitate safer water reuse, in line with the EU Circular Economy Action Plan. This workshop will draw the audience's attention to the importance of water quality for the health of humans, animals and the environment, and more importantly, to how we can become better protected from chemical risks, so as to keep pace with future water policy for the sustainable use and reuse of water.

Sampling of an aqueous film forming foam (AFFF) contaminated pond at Viktoria Fire Fighting Training Site, Uppsala, Sweden.

PHOTO BY BJÖRN BONNET, SLU

Main focus of the workshop

The goal of this workshop is to increase our awareness of the potential impact of CECs on water quality, as well as the need for developing new and existing methods and tools for identification, treatment, and risk evaluation of the contaminants in water.

The workshop will discuss the importance of protecting water quality from CECs as part of the One Health concept. This serves as a starting point to elaborate future needs by consolidating knowledge, improving assessment methods and tools, developing more efficient or new treatment techniques, and encouraging implementation of new monitoring schemes and new strategies for policy and legislation in managing the risks of CECs from source to tap.

Taking per- and polyfluorinated substances (PFAS) as a classic example of water quality regulations becoming increasingly strict, it could be that endocrine disruptor compounds (EDCs), antimicrobials and other CECs may be equally deserving of similar attention. Discussion would be of interest on the responsibility for better addressing and managing the presence and risks of CECs in water and in water for reuse. The workshop will raise awareness concerning CEC impacts and how to detect them at an early stage on various societal arenas, and thus serve as a platform to facilitate discussion and communication between policymakers, industries, politicians, non-governmental organizations and academic research in water quality with concerns to CECs.

Background

Our waters are polluted with contaminants of emerging concern

Because chemicals are beneficial to modern society and modern daily life, the number and amount of chemicals have kept increasing over the past decades (ACS, 2023). During their life cycle, these chemicals can reach the aquatic environment, including sources of drinking water production and recreational waters (Gobelius et al., 2018; Sorengard et al., 2022; Troger et al., 2018). Pollution with CECs is an important health issue, because their fate and behaviour in the environment as well as their potentially harmful effects on humans, animals and the environment are still not fully understood (Malnes et al., 2023; Oskarsson et al., 2021; Yu et al.,

2022). Some CECs give rise to important health issues, such as antimicrobial substances that raise concerns about antimicrobial resistance (Lai et al., 2021; Löffler, 2023), and PFAS that are present in drinking water owing to ubiquitous pollution and inefficient removal with conventional water treatments (Troger et al., 2018).

Focus on persistent and mobile (PM) chemicals

Previously, the concerns about hazardous chemicals in the environment were focused on synthetic compounds with 'persistent, bioaccumulative and toxic' (PBT) properties or 'very persistent and very bioaccumulative' (vPvB) compounds. We propose that three main observations during the past decades have revealed that this focus must be widened: i) the discovery of PFAS in drinking water, ii) elevated levels of pharmaceuticals and other potentially toxic substances downstream of municipal treatment plants, and iii) the risk for development of antimicrobial resistant genes (ARG) downstream of wastewater treatment plants (WWTPs). It has been shown that compounds with 'persistent, *mobile* and toxic' (PMT) and 'very P and very M' (vPvM) characteristics are overlooked groups of hazardous chemicals that pose a threat to aquatic ecosystems and human health. PFAS, pharmaceuticals, currently used pesticides, personal care products and industrial chemicals are all examples of groups of chemicals that have PMT and vPvM properties. Nowadays, it is well recognized that PM pollutants require special attention if we are to protect our waters from harmful substances.

PFAS

One of the most problematic PM classes is PFAS, sometimes referred to as 'forever chemicals' due their extreme persistency. PFAS are a group of >5000 chemicals that are used in many different consumer and industrial products such as textile, paper products and aqueous film forming foam (AFFF). PFAS have received global attention due to their PM characteristics and ubiquitous distribution in the environment (Ahrens, 2011). In particular, the presence of PFAS in drinking (raw) water has increased the global attention paid to PFAS and led to guidelines on PFAS in drinking water (Gobelius et al., 2018). Nowadays, PFAS are also used as model substances to validate current and development of new treatment techniques for removal of PFAS in, e.g., wastewater and drinking water (Franke et al., 2021).

Inefficient treatment by natural and technical barriers

Today's wastewater and drinking water treatment plants are not designed to remove organic micropollutants with PM characteristics, and it is well known that PM substances slip through from source to tap without being detected in regular monitoring. Additionally, PMT substances are overlooked in the treatment of stormwater from urban areas and roads, landfill leachate, and industrial waste waters, etc. PM substances also slip thorough natural barriers, such as percolation through soils and managed aquifer recharge (MAR) systems (artificial infiltration for drinking water production). Thus, there is an urgent need for more comprehensive characterization and monitoring of natural and treated water and their pollution sources focusing on PM substances and ARG.

Methodology for Early Warning Systems (EWS)

The vision for the future is to implement Early Warning Systems (EWS) on the national and EU level to identify hazardous chemicals at an early stage, to eventually ensure the protection of environmental and human health. The purpose of an EWS for chemicals is to establish sustainable and sensitive capacities for the early detection of hazardous chemicals in different environmental compartments (Altenburger et al., 2015). A functional EWS needs to have rapid access to various types of data, including environmental monitoring data and data on such chemicals' toxic effects. Therefore, suspect and non-target mass spectrometry screening, effect-based monitoring and effect-directed analysis (EDA) can be used as early warning monitoring tools (Menger et al., 2020). In particular, the combination of effect-based methods and chemical analysis is useful for identification of hazardous chemicals (Brack, 2003). Furthermore, often there is a lack of data on the properties of chemicals, such as persistency, bioaccumulation, mobility and toxicity. The research areas of *in-silico* modelling and artificial intelligence (AI) are under rapid development in relation to predicting these parameters (Jeong and Choi, 2022). *In-silico* models can also be used to prioritize CECs (such as PM compounds) from chemical inventory databases.

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Suggested Reading

ZeroPM, a research project funded by EU's research and innovation funding programme, Horizon 2020. Welcome to ZeroPM - ZeroPM

Water JPI Knowledge Hub on CECs Policy Brief "*Contaminants of Emerging Concern - an emerging risk in our waters*" - June 2019 - for download here.

Water JPI Policy Brief on "*What is contaminating our waters next? Contaminants of Emerging Concern (CECs) – novel ways to reduce their human and environmental risks*" - October 2018 - for download here.

Water JPI Knowledge Hub on CECs Stakeholder Brief "*Continuous increase of CECs in the anthroposphere as a stressor for water resources"* – January 2020 – for download here

Water JPI Knowledge Hub Key Achievements – for download here

Workshop G

A Global Plastics Treaty and Beyond

How Can Legal Instruments Most Effectively Contribute to Eliminating Pollution from Plastics and Chemicals at Large?

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Introduction
Chemical and plastic pollution has costly and devastating impacts on human health and biological diversity. Although the levels of some hazardous substances have decreased owing to laws and policies limiting their use, the gap between the existing situation and internationally agreed-upon goals is immense, despite the impressive growth of knowledge in recent years (Karlsson & Gilek, 2020; 2016). The main reason for lack of progress is policy failure, not least on the international level.

Aim of the workshop
This workshop explores various options to improve global chemicals governance, with a focus on public policy and international law. Against the background of experiences with the present Basel, Rotterdam, Stockholm and Minamata conventions, and the SAICM, the workshop will first discuss the emerging global plastic treaty, which the UN Environmental Assembly has resolved to put forward by the end of 2024. What objectives, principles, obligations and institutional and processual components are required for controlling plastic-generated pollution? Second, the workshop will explore the prospects for developing a more coherent global framework for governance of hazardous chemicals. Is an international framework convention for chemicals needed, and how could such a treaty be designed? We will develop concrete, scientifically informed, policy recommendations for using law to reduce hazardous substances in the environment.

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Background

Plastic pollution

Plastic pollution is widely acknowledged to be one of the most pressing environmental problems globally. It is a threat to life and the stability of earth systems and processes both in water and on land. Microplastics and chemicals associated with plastics harm both biodiversity and human health. The impact of plastic pollution in marine environments has been particularly severe and, without radical policy changes, may continue to grow exponentially (Eriksen et al., 2023), with dire consequences for aquatic ecosystems and global health in general. Measures that seek to reduce plastic pollution can also exacerbate other environmental problems. Recent research has demonstrated, for example, that the recycling of plastic can result in increased microplastic pollution in the water, air, and, eventually, our bodies (Brown et al., 2023). Biodegradable plastics and bioplastics may likewise lead to as many pollution problems as they purport to solve (Pascoe Ortiz, 2023). While the problem of plastic pollution is urgent, it is also important to proceed cautiously in implementing potential solutions before the impact of those solutions can be adequately assessed. Moreover, the chemical content of plastics must also be addressed, not only the litter dimension.

Legal solutions

A multitude of current, proposed, and developing legal instruments have been used in an attempt to mitigate harmful plastic pollution. The UN Sustainable Development Goals, adopted in 2015, contain several goals and targets related to this issue. Goal 12, for example, calls for sustainable consumption and production; measures pursuant to this goal include targeting plastics and encouraging circular economies. Goal 14 calls for the conservation and sustainable use of oceans, seas, and marine resources. A target under this goal requires significant reduction of all kinds of aquatic pollution by 2025. However, the UN's 2022 report on progress towards its goals found that, to the contrary, in 2021 "more than 17 million metric tons of plastic entered the world's ocean, making up 85 per cent of marine litter. The volume of plastic pollution entering the ocean each year is expected to double or triple by 2040." Goals alone are too porous to have the desired impact.

Many new laws have been enacted that respond to or are at least complementary to the sustainable development goals. In the EU, for example, the 2019 Single Use Plastics Directive aims to reduce the impact of plastic waste on the environment. The European Green Deal promises more drastic measures to achieve a goal of "zero pollution." Whether movement towards this goal will survive the evolving political climate remains to be seen.

Significantly, negotiations are underway within the UNEP to draft "an international legally binding instrument on plastic pollution, including in the marine environment," which it has committed to producing by the end of 2024. Hopes are high that this legally binding, global treaty will be able to reverse the long-standing trend towards environmental degradation.

Laws as tools

Laws can be important tools for achieving environmental goals, but if they are to succeed, they must be formulated appropriately, as well as implemented and enforced (Epstein & Kantinkoski, 2020). Many international agreements currently in force, such as the aforementioned Basel, Rotterdam, Stockholm and Minamata conventions, have attempted to mitigate chemicals pollution, but have not been able to stop planetary boundaries from potentially being exceeded (Persson et al., 2022). Likewise, the proliferation of environmental laws at national and regional levels has not yet had the intended effect of curbing pollution (UNEP, 2019). How can a new plastics treaty succeed when so many laws and policy instruments have fallen short? Can the problems with existing laws and policies be found in their goals, their formulation, their implementation, their monitoring or enforcement mechanisms, or something else? And would yet another partial treaty be sufficient for addressing chemicals pollution, or would a global framework convention be needed, targeting hazardous substances more broadly, as done in EU and national law as well as in other areas of public environmental governance (Tuncak & Ditz, 2013)? Legal scholars have suggested a number of reasons why environmental laws have not been optimally effective, or could be more effective (e.g., Pontin et al., 2023; Epstein et al., 2023; Laitos & Wolongevicz, 2014). Similarly, environmental governance research has pointed out mechanisms in the science-policy spheres that delay goal achievement (Karlsson & Gilek, 2020). In this workshop, we bring together legal, scientific, and policy expertise to make policy recommendations for better plastic and chemical pollution laws.

Questions to be addressed

This workshop will use roundtable and small group discussions to investigate the following questions:

- What legal principles and mechanisms are necessary or desirable for an international agreement on plastics to be effective in achieving pollution-related goals?
- What kinds of legal and other policy mechanisms are necessary or desirable for regional or national laws – laws that implement or are independent of an international agreement – to be effective in achieving their goals?
- Are different types of laws or policies more appropriate for certain types of countries, such as most developed and developing countries, respectively? What kinds of regional and local factors must be taken into consideration?
- Are there aspects of plastic pollution that are not currently being given sufficient attention in discussions on legal instruments? How can hazardous substances in plastics, microplastics, plastic recycling, plastic decomposition and other facets of plastic pollution be adequately considered?
- Are there important lessons from the creation or implementation of previous and current chemical treaties and laws that should help inform the creation of new plastics laws?
- Is a stringent global framework for hazardous chemicals needed to more effectively and comprehensively address chemicals pollution, while at the same time creating a level playing field for businesses?

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Workshop H

Managing Emerging Health Risks in the Feed and Food Chain

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Introduction

In an ideal world, a proactive society would protect its population from hazardous pollutants by preventing their release. This, however, is not always possible. Sometimes risks are overlooked and not acted on in time to prevent human exposure. In other cases, misconduct, greed or even the intention to do harm may result in the release of pollutants. Finally, a contamination may be, from the outset, the result of a trade-off between conflicting goals, for example when medical products reach the environment via sewage water or when pesticides are allowed as a means of reducing harvest losses and food spoilage.

In such situations, being proactive is a matter of being prepared to minimize harm to society. This may not only involve minimizing the health effect from the pollutant itself, but also involve a trade-off between most of the 17 global sustainability goals. For example, the widespread withdrawal of contaminated food could affect food security (e.g., Goal 2), and the crisis could challenge citizens' trust in public institutions (Goal 16).

Thus, a proactive society must also be prepared to manage a situation in which preventive measures have failed.

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Focus of the workshop
This workshop will explore emerging health risks in the feed and food chain, with a specific focus on risk analysis and effective communication between risk assessors, risk managers, and the public.

An emerging health risk in this context would be a chemical that is brought to attention either by health effects in animals or humans, for instance acrylamide, or by being detected in the environment, such as PFAS (per- and polyfluoroalkyl substances). During the workshop, we will discuss strategies for effective preparation and management of future emerging risks in the feed and food chain using the lessons learned from historical events.

Examples of aspects to discuss include, but are not restricted to:

- From a global perspective, how can we balance conflicting goals in the feed-food chain, such as protecting consumers from health hazards while minimizing the impact on the food industry and avoiding food shortages?
- How can a risk assessor support a risk manager in situations when information is uncertain?
- How and what should be communicated to the public and other stakeholders in situations where outcomes are uncertain?
- In a crisis, how do we determine what level of safety is "safe enough" for consumers? What does "zero tolerance" mean, and how can we manage the discovery of trace levels of contaminants?

The goals of this workshop are to:

- Foster a proactive mindset among risk assessors and managers, to effectively manage complex health threats in the feed and food chain.
- Exchange experiences from different parts of the world and identify areas where research and further knowledge are needed.
- Facilitate networking and collaboration between individuals and organizations with diverse roles and expertise in the feed and food chain.

Background

Chemical pollutions in the feed-food chain

The largest health hazards in the feed-food chain are "natural" substances such as mycotoxins. But occasionally pollutants find their way into the food chain. Contamination could occur during primary production or later in the chain, for instance during transport.

History has numerous examples of consumers who have been exposed to chemical pollutants. In many cases, the pathway has involved contaminated animal feed.

In 2008, a large number of pigs in Ireland were exposed to dioxin, the source of the contamination being traced to an animal feed production facility that was using hot gases from the combustion of contaminated fuel oil to dry animal feed. As a result, the Irish government ordered a recall of all pork products produced in the country. Thousands of pigs were also culled as a precautionary measure. More recently, dioxins have been found in eggs following the use of fish meal from the Baltic Sea as a component in poultry feed. Attention was first brought to acrylamide as a food contaminant during construction of a railway tunnel through the ridge Hallandsåsen in southern Sweden. Fish died and cattle that drank from the streams suffered paralysis due to leakage of a chemical grouting agent (Reynolds 2002). When the exposure of workers and local citizens was investigated, it was discovered that acrylamide can be formed when foods are heated to high temperatures (Reynolds 2002). During the past years, PFAS has emerged as a potent class of contaminants in feed and foods (EFSA 2020). While these chemicals have been used since the 1950s, it was not until the 2000s that their widespread occurrence, at concerning levels, in the environment became known, and they have recently been identified as a public health concern due to the contamination of drinking water and food.

Challenges for decision-making

A rise in new food- or waterborne health hazards will create challenges for authorities at the national, regional, and municipal level. It is not only that decisions must be made that balance the potential public health risk against other values such as food security, economy and the sustainability of the society and agriculture. Authorities in different countries must also communicate the risk to the public and other stakeholders in an appropriate and effective manner. Playing down a risk that later turns out to have a public health impact is detrimental to public trust, as experienced in the case of PFAS. At the other end, the public perceiving the risk to be greater than it is may cause a social stigma for the commodity (as well as affecting public trust in the authorities). In low-income countries, such a stigma may result in food insecurity, which may have a greater impact on health than the chemical risk itself. One example was when social media picked up that the toxin aflatoxin M1 occurred in milk in Ethiopia, which caused many consumers to fear drinking milk, resulting in severe economic impacts and loss of nutritious food in a food-insecure country. On the other hand, as a high-income country, Sweden has been able to afford maintaining a very high level of protection for half a century (Dernfalk et al. 2022).

This contrast can be exemplified with dioxins in Baltic Sea fish, where a historically important source of food has been almost abandoned due to elevated levels of dioxin-like compounds and largely replaced by imported fish (Pihlajamäki 2018). This illustrates the equality dimension of food safety, where the most affluent countries can afford a very high standard by importing premium products. However, as history shows, reliance on imports is likely to result in shortages in times of war or financial crisis. When the Covid-19 pandemic arose, it was discovered that making trade-offs with public health was very controversial. Society might not be mentally prepared for trade-offs if it turned out that an emerging chemical hazard was widespread in a commodity that cannot easily be replaced, or if importing that commodity was not possible for some reason.

In addition, the ethical dilemmas associated with adapting to a situation with a widespread pollutant may also come into conflict with legislation. Discussions in the EU commission on legislative limits for mycotoxins have raised the question of whether legislative limits could be adjusted if a large part of the harvest were affected by moulds during a bad year, but at present this is not an option. Conflicts with legislation may be a particular challenge for prohibited substances for which no regulatory limit exists. For instance, a prohibited substance may enter

the food chain because of misconduct or fraud, as was the case in the horse meat scandal where horses treated with phenylbutazone were sold as beef (EFSA 2013). When the banned antibiotic chloramphenicol was detected in slaughter-ready pigs in Sweden in 2012 (Aspenström-Fagerlund 2016), the contamination was most likely due to the substance being produced naturally by bacteria present on straw used as bedding. In neither of these cases was there any health risk from the contamination, but it put decision-makers under substantial pressure, and in the case of phenylbutazone, the economic consequences were great.

Challenges for risk communication

Managing emerging risks in the feed-food chain presents significant challenges for risk communication, putting international, national, regional, and local authorities under severe stress (Focker et al. 2021). Effective communication between risk assessors and risk managers is crucial, particularly regarding how requests for expert opinions are phrased to support informed decision-making and public communication. Management options must be evaluated, with metrics allowing for comparison with familiar risks to facilitate decision-making and effective communication.

What does it mean to be proactive?

In an ideal world, a proactive mindset would prevent pollutants ever entering the food chain, and decision-makers would never need to compromise with health risks. However, experience has shown us that new risks will emerge, sometimes because of bad policy but also possibly as a result of events beyond our control. When this happens, authorities must act to minimize the consequences, something that may involve making difficult trade-offs.

Preparing for joint evaluation of management options and communication strategies will better equip authorities and society to manage crises related to foodborne health risks and is an essential part of proactive risk management. Managing a crisis with widespread chemical pollutants in the food chain will also require appropriate legal tools. While it might seem controversial to prepare "crisis legislation" that permits "controlled" exposure of consumers to hazardous substances, it may still be better than the alternative of overruling legislation on the fly or looking away. One lesson learnt from the Covid-19 pandemic is that legislation aimed at ensuring competition, for example, the need for procurement, can significantly slow down mobilization of the private and public resources needed for managing a crisis, again pointing to the need for "legal preparedness".

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Workshop I

Metabolic Diseases

From Chemical Exposure to Interventions

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Introduction and main focus

During the past two decades, research has cemented the idea that the exposure of human and other animals to specific contaminants in the environment can trigger metabolic diseases (Lind, L et al., Alonson-Magdalena, P et al. 2016, Gore, A. C. et al.). Despite this evidence, much of public health work and policies related to metabolic disease around the world are based solely on the genetic, nutritional, and physical activity aspects. Although these aspects certainly play a fundamental role in our understanding of metabolic diseases, obtaining a complete picture of the causes of metabolic diseases requires incorporating the environmental exposure aspect. This knowledge can have profound implications in developing new and effective public policies, at the regulatory and educational levels, aimed at tackling the increasing global incidence of metabolic diseases. For this to occur, however, it is of utmost importance to establish clear connections between exposure to contaminants and metabolic diseases in human populations. In this workshop, we will gather experts from different backgrounds to promote an evidence-based discussion on the role of exposures to contaminants in the incidence of metabolic diseases in humans. This will be coupled with identification of gaps in public health work and policies, and proposals for improvements, based on incorporating the exposure aspect to tackle the global increase in metabolic diseases.

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Background

Metabolic diseases, in particular obesity and related diseases like type 2 diabetes mellitus (T2DM) and cardiovascular disease (CVD), have increased during the past few decades across age segments, in both sexes, and in both low- and high-income countries (Collaboration, N. C. D. R. F. *Lancet* (2017), Ng, M. *et al.*). Interventions aimed at tackling metabolic diseases around the globe have included identification of related genetic variation, dietary policies, as well as encouraging physical activity, as exemplified in a recent Cochrane review of obesity prevention in children (Brown, T. *et al.* 2019. Despite this, obesity trends have at most attenuated in some countries, and no country in the world has been able to reverse the incidence of obesity Collaboration, N. C. D. R. F. *Lancet* (2017), Ng, M. *et al.*). Importantly, conditions associated with metabolic diseases, including CVD and T2DM (Brenseke, B. *et al.*, MacDonald, A. A. *et al.*, Somer, R. A. & Thummel, C. S.), are the leading causes of morbidity and mortality in the world (WHO, 2020).

Based on this, the fundamental question posed to us as a society is how we can effectively tackle this burden of metabolic diseases. One suggestion for answering this question comes from recent evidence showing that the etiology of most non-communicable diseases is related to environmental exposures during embryonic development or infancy, on top of genetic variation that could explain susceptibilities in certain groups (Guerrero-Bosagna, C. & Skinner, M. K.). This is in line with the concept of Development of Origins of Health and Disease (DOHaD), the main aim of which is to understand how the incidence of diseases can be rooted in exposures occurring early in development (Wadhwa, P. D. *et al.*). Many of the compounds affecting our lives early in development involve endocrine-disrupting chemicals, which mimic the action of our hormones when binding to cell receptors (Jacobs, M. N. *et al.*). Because these compounds involve the main components of many daily life products such as plastics, electronics, pesticides and agrochemicals, they have become environmental contaminants (Jacobs, M. N. *et al.*).

Residues of endocrine disruptors can persist in the environment for many years, bioaccumulate in organisms, and have detrimental effects on ecosystems, in general, and on human health, in particular. Additionally, bioaccumulation of many of these toxicants is known to occur in organisms used to feed human populations, such as fish, shellfish and vegetables. The importance of investigating environmental contaminants is so great that the World Health Organization has determined that understanding their effects is of high priority (WHO/UNEP 2012). Despite these detrimental effects, the yearly production of new chemicals, many of which will have endocrine-disrupting properties, is alarming. Of the tens of thousands of chemicals in the marketplace, only around 2500 have been evaluated for their health effects(Gore, A. C. *et al.*).

In relation to metabolic disease, the causes underlying their global increase are now known to be multifactorial, including well-know factors such excess calorie intake, food composition, physical inactivity, but also 'other factors' (Morgen, C. S. & Sorensen, T. I., Brown, R. E. *et al.* 2015). There is now plenty of evidence showing that these 'other factors' include exposure to environmental contaminants, as many of them are reported to be involved in the etiology of obesity (Gore, A. C. *et al.*, Gore, A. C. *et al.* 2009) and diabetes (Alonso-Magdalena, P. *et al.* 2011, Hectors, T. L. *et al.*). This current evidence follows years of research initiated by pioneering work in the 2000s that led to introduction of the term 'obesogens' to describe environmental compounds that can trigger metabolic diseases (Grun, F. & Blumberg, B. 2006). At present, this concept is well-supported by experimental evidence in both human and lab animal studies (Lind, L. *et al.*). One important fact emerging from studies investigating the obesogenic effects of environmental contaminants is that such effects are dose- and age-dependent. Additionally, many reports have also shown that the metabolic disruption produced by environmental contaminants can be transmitted across generations (Guerrero-Bosagna, C. & Jensen, P., 2015). For example, experiments involving developmental exposure to the well-known pesticide Dichlorodiphenyltrichloroethane (DDT) in rodents have shown that obesity, measured as the acculturation of abdominal fat pads, increases three generations of the exposure (Skinner, M. K. *et al.*). Alarmingly, this phenomenon is not observed in the generation that was developmentally exposed, showing that these effects can be hidden in the epigenome of the gametes until they are expressed generations after the exposure (Alonso-Magdalena, P. *et al.* 2016).

The idea of using policy interventions to address exposure to endocrine disruptions, and thereby to tackle metabolic diseases, is in its infancy. A recent systematic review, however, has shown high-quality evidence supporting the idea that changes in nutritional and other daily habits can successfully reduce exposure to endocrine disruptors (Corbett, G. A. *et al.*). These habits include dietary alterations such as consumption of organic food, avoidance of canned food and beverages, modification of behavioral patterns in relation to personal care products, as well as avoidance of plastics (e.g., using glass or stainless-steel bottles and containers instead of plastic) (Corbett, G. A. *et al.*). This study emphasizes the idea that societal interventions relation to education and/or regulatory policies aimed at reducing exposure to endocrine disruptors can have the tangible effect of reducing exposure. The question is whether this would also be reflected in a reduction in the incidence of metabolic diseases, and to what extent. Additionally, there is the issue of how such interventions could be integrated into current strategies focused on nutritional and physical activities, thereby increasing the overall efficacy of societal interventions in this realm. This workshop will establish a conceptual basis for future development of societal interventions aimed at reducing exposure to endocrine disruptors, the goal being to help tackle global increases in metabolic diseases in humans.

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