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Backstory

Emerging questions in exposure, regulation, and remediation of PFAS

Rainer Lohmann[1] and Elsie Sunderland[2,3]

The monitoring and remediation of persistent chemicals, such as poly- and perfluoroalkyl substances (PFAS), consist of many moving parts: advancing technologies, regulatory questions, and the understanding of environmental and health effects. The research related to PFAS, however, does not stay in the laboratory. It is affecting many communities directly and has entered the public's eye in a way not many research areas do. However, the research field is made up of many different disciplines that first must communicate effectively between each other, in order to then communicate outward.

Two leading scientists working on this cross talk between disciplines when it comes to research related to PFAS and other persistent chemicals are Prof. Rainer Lohmann (University of Rhode Island) and Prof. Elsie Sunderland (Harvard University). Both, in seeking to understand how their work functions as part of the broader field, especially considering emerging regulatory questions, are not shy to collaborate across disciplines and communicate with affected communities.

Elsie Sunderland (left) and Rainer Lohmann (right) are leaders of their fields considering the environmental and health effects of persistent chemicals in the environment. They seek out interdisciplinary collaborations regularly to understand how their work interfaces with affected communities, regulatory bodies, and human health.

The two have, together with the editorial team at *iScience*, put together a special collection focusing on the many disciplines focused on PFAS research (https://www.sciencedirect.com/journal/iscience/special-issue/103M77PRPGG). From environmental science and earth science to chemistry and engineering, to also issues of policy, environmental justice, and the role of industry, it is obvious that research in this field consists of many moving parts that affect researchers and the public. In this backstory, we discuss with Lohmann and Sunderland their entry into the field, the state of the field right now, and where it may be headed in the coming years. We also touch on advice to rising researchers in this field, and where they too can find an opportunity to make an impact.

FIRST IMPRESSIONS

What originally interested you in the field of persistent chemical pollutants? Did you train in this area or are your research interests naturally aligned with the developing field?

Sunderland: When I was in high school a toxic waste incinerator tried to move into my small rural community in Canada. I started reading and understanding some of the implications of this and was appalled. This kickstarted my career in this area. I initially studied chemistry and environmental sciences and pursued a PhD in environmental toxicology.

Lohmann: I became interested in persistent organic pollutants when I learned about their many nasty effects on humans and the environments, and their global transport. This was partially why I wanted to study environmental chemistry, though that was not a fully accredited course of study at the time, so I combined training in analytical chemistry, environmental engineering, and environmental science throughout my studies. Initially, I was working on semi-volatile organic chemicals, including polychlorinated biphenyls (PCBs), dioxins, and organochlorine pesticides. I switched my attention to PFAS only in the last decade or so.

Is your experience like that of your colleagues in the field? Why does a scientist choose to work in this field?

Lohmann: I work at interface of analytical chemistry, environmental engineering, and marine science. Most colleagues in the PFAS-field have a strong chemistry and/or engineering background and training. Given the prominence of PFAS in the news, and concerns for human health, state and federal demand for action on PFAS is very high. Working on PFAS has thus become a high priority research field for many scientists and engineers to contribute new knowledge, develop new tools or to help remediate contaminated sites.

Sunderland: My research is highly interdisciplinary and includes exposure and risk analysis. Many of our colleagues have diverse backgrounds and work together to address the interdisciplinary challenges associated with PFAS contamination, that Rainer highlights. I think young scientists choose this field because they care about the environment and its connection to public health.

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MOTIVATION

What are the most important or exciting questions in the field currently, and why do they matter? What do you think are the biggest challenges that the field is facing?

Lohmann: Major questions that are pressing concern the analytical challenges of deciphering the various PFAS out there, any transformation products, and associated effects. PFAS are the ideal class challenging our regulatory approach to test each substance individually before taking action. Even with modern high-throughput screening assays, a paradigm shift is needed to focus on these compounds as belonging to a class, and they ought to be regulated as such. For society at large, a major challenge will be on how to effectively remediate the thousands of contaminated sites across the US. This will provide ample opportunity for novel treatment approaches and innovative engineering solutions.

Sunderland: I think one of the largest gaps right now is understanding the importance of different exposure pathways for the general population. For example, near contaminated sites we know that drinking water is the main source of exposure but for individuals who live outside of these areas personal care products, and dietary sources, among others can also be substantial. The US Food and Drug Administration recently

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announced that they did not consider PFAS in the US food supply a concern based on preliminary data and I think this jumps the gun before we have representative data on concentrations of these chemicals in our food supply. In Europe, there is substantial data for diverse PFAS in many different foods. I also think we are going to discover more and more concerning health effects associated with exposures to some of the newer PFAS being produced today and we need to consider different strategies for regulating these compounds such as a class-based approach, so we are not indefinitely playing 'chemical whack-a-mole'.

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INTERDISCIPLINARY METHODS

What role does interdisciplinarity play in the context of this field? What suggestions would you give to a rising scientist interested in this area?

Lohmann: Interdisciplinarity is, like in many other science fields, a key to breakthroughs and success. I don't see interdisciplinarity is a barrier, but rather an enabler for more relevant science. Plenty of progress on PFAS is still performed within classical fields, e.g., analytical detection of PFAS; toxicological assays, new remediation tools, etc. Yet, some of the higher-level projects and insights are often achieved when people collaborate across disciplines, such as relying on new tools to better assess exposure, or understanding what the presence of novel PFAS in foodwebs might mean for the health of animals in the wild.

Advice for a young scientist? Pick a topic that interests you, so that you have fun while you work hard; build connections to others in your and adjacent fields and be open to collaboration.

Sunderland: I think it is important to be grounded in a field when you begin your career such as chemistry and/or math/physics and then you can become broader and broader as your career progresses. Mind you, this is not what I did when I was a young scientist - since I was really interested in working with people and communities and regulators right away. So basically, I would say follow your interests and persevere and things will work out.

What are other disciplines that should look to this field with interest? Which new communities do you see forming in the future around the topics the field is interested in?

Sunderland: I think the issues around PFAS contamination and their regulation presents a microcosm for the challenges associated with the extensive use anthropogenic chemicals in society. We are now dealing with the health costs of the "better living through chemistry" era in the 1950s when many persistent organic pollutants were first manufactured and used for their useful properties in a myriad of products – only for us to realize decades later that they had harmful impacts on human health and the environment. I think if we can figure out how to address some of the challenges associated with PFAS production and use – we will also be developing a framework and infrastructure to address similar challenges posed by other chemical classes.

Lohmann: Given the tremendous physical and mental toll affected communities have experienced due to their exposure to PFAS, there is an unusually strong connection between citizens and scientists, and I hope that bond will strengthen over time. There are several Agency for Toxic Substances and Disease Registry (ATSDR) studies ongoing with communities and health monitoring, and those might reveal additional relationships between exposure and health outcomes. At the same time, being in communication with affected citizens reminds scientists like me regularly why we chose this profession in the first place. Not only to perform some abstract scientific studies but also help reduce the impact of nasty chemicals on humans and the environment.

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On the engineering side, I hope to see further collaboration between engineers, scientists, and practitioners to put into field trials some of the more promising approaches of removing and destroying PFAS from contaminated sites and media.

FUTURE

What breakthroughs do you imagine or hope to see in upcoming years?

Lohmann: There are some wicked political questions on how to deal with PFAS – from a regulatory perspective, legislation, but also on the end user side. Can you treat them as a class of compounds, thereby overcoming the one chemical at a time approach to legislation? Is it possible to identify non-essential and substitutable uses of PFAS and thereby quickly reduce demand on PFAS in products, and help lower exposure? Are breakthroughs possible in terms of remediation to deal with the hundreds of contaminated sites across the US? Will the high-throughput toxicity assays developed and pursued by the U.S. EPA lead to new insights with respect to potential mechanisms, effects, and priorities for action?

Sunderland: I agree with Rainer – I would like to see these compounds regulated as a class and I would like to see our community adopt a variety of analytical methods for screening for all of them and then using more sophisticated tools to understand their composition/concentrations in areas of concern. There is a lot of work to be done improving methods for chemical detection and remediation of these compounds. We also need to leverage from computational toxicology tools, in my opinion, to better understand the potential health impacts of exposures to the newer PFAS, the outcomes associated with PFAS mixtures, and screen for problems before we have population-wide exposures and effects. There is a lot of promising work in this area that I hope will transform the way we can talk about potential health risks.