

Current Knowledge and Needs for Assessing the Ecological Risks of PFAS: Overview of an International Workshop*

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*Content does not necessarily reflect EPA position or policy.

Ecological Effects of PFAS: An Emerging Emphasis

- PFAS contamination from multiple sources in aquatic and terrestrial ecosystems throughout the world
- Many (100s/1000s) PFAS in multiple structural classes, most with inadequate data to assess possible ecological occurrence/toxicity
- Some PFAS persistent/bioaccumulative/toxic
- Ongoing/increasing efforts on PFAS ERA and regulation throughout the world
- Efforts by US Federal/State programs to assess presence and effects of PFAS in the environment (e.g., DoD, EPA, DOI; MN, MI, VT, NH, FL)



Environmental Risk Assessment of PFAS

12–15 August 2019 | Durham, NC, USA

SETAC North America Focused Topic Meeting

Four-day workshop with expert presentations and topic group
breakouts/discussions

Topic groups: Analytical Chemistry; Exposure; Human Health Effects;
Ecological Effects; Risk Characterization

Open forum discussions with tripartite representation—business,
academia, government

Ecological Effects Topic Group: Basic Approach


- Platform presentations by experts in the field (Day 2)
 - General ERA needs and specific activities from different regions
 - Overviews of existing data for different PFAS
 - Status of existing and new approaches for testing
- Facilitated breakout group discussions (Days 3, 4)
 - Core panel of experts
 - Approximately 80-90 “observers”
- Preparation of detailed workgroup report



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- (1) Background and Introduction
 - (2) Prioritizing for Monitoring and Testing
 - (3) Current Knowledge about Ecological Exposure
 - (4) Current Knowledge about Ecological Effects
 - (5) New Approach Methodology (NAM) Application to Date
 - (6) International Perspectives on Current ERA/Regulatory Activities
 - (7) Advancing Exposure Assessment
 - (8) Advancing Hazard Assessment
 - (9) Opportunities for Applying NAM
 - (10) Addressing the Challenge of PFAS Mixtures
 - (11) Conclusions and Recommendations

Select PFAS ERA Activities Around the World

- Canada
 - National ERAs for PFOS, PFOA, >C9 PFCAs
 - FEQGs for PFOS
- Australia/New Zealand
 - Freshwater effects guidelines for PFOS, PFOA
- European Union
 - Multiple PFOS guideline values for freshwater effects
- United States
 - Development of ALC (EPA)/Screening Values (DoD) for PFOS, PFOA
 - State guidelines for aquatic/wildlife effects (MI, MN)

Exposure Assessment: What's known and needed?

- PFAS present in variety of environmental matrices and biota
- Sometimes associated with point sources/applications, but also found in remote environments (e.g., Arctic)
- Large database for PFOS and PFOA, less (no) information for other PFAS
- Systematic monitoring data needed
 - Probabilistic sampling in variety of ecosystems
 - Data for larger diversity of PFAS
 - Information for degradates/metabolites
- Important role for nontargeted analytical techniques



Exposure Assessment: The Bioaccumulation Challenge

- Key concern/need for both ecological and human health assessments
- Some PFAS classified as POPs based on bioaccumulation; evidence of biomagnification at higher trophic levels
- Processes controlling PFAS bioaccumulation uncertain
- Lipid-based models used to predict accumulation of nonionic organics (e.g., PCBs) not appropriate for PFAS
- Data concerning protein binding, metabolism, etc. needed to build mechanistic models based on structure
- Empirical relationships (BAFs, TMFs) may be best current option to predict bioaccumulation, but data limited to a few PFAS

What do we know about *in vivo* eco-relevant effects?

- ECOTOX Knowledgebase used for data retrieval
- Aquatic invertebrate data overview
 - 47 tested PFAS; 95% PFSA, PFCAs, FPPPs; 60% PFOS or PFOA
 - Cladocerans and chironomids most frequently tested
 - Low acute toxicity (mg/L), much greater chronic toxicity in some taxa ($\mu\text{g/L}$)
 - FPPP > PFSA > PFCA; \uparrow C chain length \uparrow toxicity
- Fish data overview
 - 29 tested PFAS; >90% PFSA, PFCAs, largely PFOS or PFOA
 - Most testing in freshwater cyprinids (zebrafish, fathead minnow)
 - Similar toxicity profiles as invertebrates



***In vivo* Effects: Data Gaps and Limitations**

- Limited/no data for majority of PFAS; no information for some classes
- Much of testing done (e.g., PFOS, PFOA) focused on acute lethality not sublethal chronic effects (growth, reproduction)
- Limited data in amphibians, birds, reptiles, mammalian wildlife
- Little to no toxicity data for most invertebrate taxa, plants
- Experimental issues with many aquatic studies done to date
 - PFAS in controls, unnecessary use of solvents, static-renewal (vs flow-through)
 - Analytical verification of PFAS concentration/dose often lacking
- Field studies documenting effects (or not) sparse

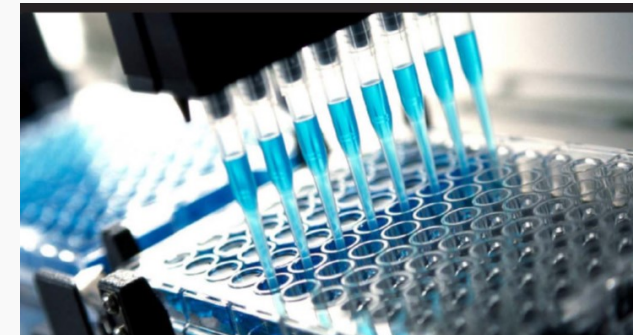
Defining a Path Forward: *In vivo* Testing

- Testing gaps abound (chemical, taxa, endpoints, lab/field) but not reasonable to address them solely through empirical testing
- Requires strategic prioritization supported by predictive tools to focus testing
 - Production volume/use, persistence, metabolism
 - Predicted/measured toxicity, bioactivity
- Identify of a “core” group of PFAS representative of different classes, and suite of potentially susceptible taxa/endpoints for “baseline” testing
 - Confirm/characterize exposure in test media and tissues



New Approach Methodologies (NAMs) for PFAS ERA

- Provides basis for predictive assessment of chemicals with limited information
- Curated databases with existing knowledge (“read-across”)
- In silico (e.g., QSAR) models
- Tools for cross-species extrapolation of effects
- In vitro (incl. HTP) measures of bioactivity
- Pathway-based measurements from short-term in vivo assays (incl. ‘omics)



Employing NAMs for Assessing PFAS Risks

- Currently feasible applications
 - Prioritization (e.g., predicting/measuring bioactivity)
 - Categorization/fingerprinting
 - Guiding testing (e.g., species/endpoint selection)
- Not yet viewed as suitable for quantitative hazard/risk assessment
- Technical uncertainties
 - Tools/assays have limited taxonomic scope (e.g., mammalian-based HTP)
- Regulatory acceptance
 - Linkage to adverse apical effects uncertain

Adverse Outcome Pathways (AOPs) in PFAS ERAs

- Depict causal response linkages across biological levels of organization
- Developed specifically to support use of data from NAMs for effects prediction
- Provides framework to assemble and share knowledge (AOP Wiki)
- Multiple ongoing efforts supporting eco-AOP development for PFAS
 - Fish, amphibians, birds, invertebrates





Assessing Ecological Risks of PFAS Mixtures

- PFAS both enter and occur in most environments as complex mixtures
- Little testing with either formulations or component (synthetic) mixtures
- Mixture testing needs
 - Defining specific PFAS “driving” toxicity of mixtures (concentration, potency)
 - Complementary analytical-toxicological studies (e.g., discover “excess” toxicity)
 - MOA/AOP-based categorization to support predictive models
- Develop/deploy nontargeted analytical techniques to identify unknown PFAS (incl. degradates, metabolites)



Summary/Recommendations

- PFAS present plausible risks to ecological systems and services
- Existing approaches for exposure/effects assessments conceptually valid but require “tailoring” to properties of PFAS
 - Toxicity assessments (in vitro/in vivo, endpoints, taxa)
 - Bioaccumulation (assays, empirical/mechanistic models)
- Data to conduct complete ERAs lacking for majority of PFAS
- Integrated predictive and empirical approaches needed to prioritize PFAS and guide PFAS testing

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- Technical and Programmatic Reviewers

For More Information

- The research discussed in this presentation is part of EPA's overall efforts to rapidly expand the scientific foundation for understanding and managing risk from PFAS.
- For more information on EPA's efforts to address PFAS, please visit the following websites
 - EPA PFAS Action Plan - <https://www.epa.gov/pfas/epas-pfas-action-plan>
 - EPA PFAS Research - <https://www.epa.gov/chemical-research/research-and-polyfluoroalkyl-substances-pfas>