SETAC Journal Club: Assessing the Ecological Risks of PFAS *

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*Content does not necessarily reflect EPA position or policy.

Environmental Risk Assessment of PFAS

12–15 August 2019 | Durham, NC, USA

SETAC North America Focused Topic Meeting

Four-day workshop with +400 attendees and mix of topic-oriented presentations breakouts/discussions, with peer-reviewed reports prepared by each topic group:

Johnson et al. Estimating environmental hazards and risk from exposure to PFAS: Outcome of a SETAC focused topic meeting

De Silva et al. Exposure pathways for humans and wildlife: Synthesis of current knowledge and key gaps in understanding

Ankley et al. Assessing the ecological risks of PFAS: Current state-of-the science and a proposed path forward

Fenton et al. PFAS toxicity and human health review: Current state of knowledge and strategies for informing future research

Mikkonen et al. Suggestions for improving the characterization of risk from exposures to PFAS

Environmental Toxicology and Chemistry, March 2021, Highlighted Issue on PFAS Risks

Eco-Effects Expert Group

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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 structural groups
  - Information for degradates/metabolites
- Important role for nontargeted analytical techniques

Exposure Assessment: The Bioaccumulation Challenge

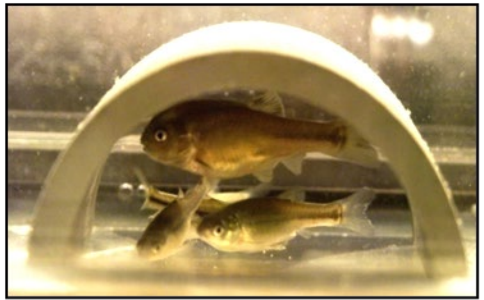
- Key concern/need for both ecological and human health assessments (e.g., fish consumption advisories)
- Some bioaccumulate and a few also biomagnify in food webs
- Processes controlling PFAS bioaccumulation uncertain
- Lipid-based models used to predict accumulation of nonionic organics (e.g., PCBs) 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% PFSAs, PFCAs, FPPPs; 60% PFOS or PFOA
  - Cladocerans and chironomids most frequently tested
  - Low acute toxicity (mg/L), much greater chronic toxicity in some taxa (µg/L)
  - FPPP>PFSA>PFCA; ↑ C chain length ↑ toxicity
- Fish data overview
  - 29 tested PFAS; >90% PFSAs, 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

Defining a Path Forward: Application of NAMs

- New approach methods provide basis for predictive hazard assessment of chemicals with limited information/capacity for in vivo testing
- Curated databases with existing knowledge (“read-across”)
- In silico (e.g., QSAR) models
- Tools for cross-species extrapolation of effects
- In vitro (incl. HTT) measures of bioactivity
- Molecular/biochemical measurements from short-term in vivo assays

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)
- Greatest current challenge is lack of data needed to conduct complete ERAs for majority of PFAS
- Integrated predictive and empirical approaches needed to prioritize PFAS and guide PFAS testing