

Environmental exposures and health impacts of PFAS

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Presentation Outline

- Introduce per- and polyfluoroalkyl substance (PFAS)
 - what are they?
- Discuss chemical properties of PFAS
 - why are they useful?
- Review what is known about routes of human exposure
- Describe animal and human health effects of PFAS
- Summarize national and international regulatory efforts to control their use
- Long-term outlook regarding PFAS

Per- and Polyfluoroalkyl Substances (PFAS)

- Synthetic analogs to long chain fatty acids – but fluorine is used in the place of hydrogen
- PFAS are entirely manmade – no natural sources and literally thousands of different formulations in use
- Many PFAS are extraordinarily persistent in the environment, cannot be broken down by natural systems
- PFAS are detected in all environmental media – air, water, soil, sludge
- Like other persistent organic pollutants, many PFAS bioaccumulate in animals at the top of the food chain – birds, fish, livestock, and humans
- Environmental persistence leads to global distribution via air and water movement – releases here can be significant for communities on the other side of the world

Sources of PFAS exposure for humans

- Best documented source is contaminated drinking water near industrial production facilities or waste disposal e.g., Cottage Grove, Minnesota; Parkersburg, West Virginia; Dalton, Georgia; Decatur, Alabama; Arnsberg, Germany; Osaka, Japan *Lindstrom et al. 2011, Environ. Sci. & Technol. (45) 8015 – 8021*
- Food is also implicated in many studies, especially fish from contaminated waters, items contaminated by food packaging, and breast milk *Fromme et al. 2009, Inter. J. Hyg. & Envr. Heath (212) 239-270; Mogensen et al. 2015, Environ. Sci. & Technol. (49) 10466 - 10473*
- House dust may also be an important route of exposure – especially for children who ingest relatively higher levels of dust via hand-to-mouth activity *Shoeib et al. 2011, Environ. Sci. & Technol. (45) 7999 - 8005*
- Workplace exposures significant for some sectors: manufacturing or services making or directly using PFAS, apparel sales, waste treatment *Nilsson et al. 2013 Environ. Sci.: Processes Impacts, 15, 814-822*

PFAS Health Effects Summary

- These chemicals not only persist in the environment, but also inside the body once ingested, particularly in humans

Serum half-life	PFBS (C4)	PFHxS (C6)	PFOS (C8)	PFBA (C4)	PFHxA (C4)	PFOA (C6)	PFNA (C9)
Mouse	5 hours	30 days	40 days	12 hours	2 hours	20 days	60 days
Humans	28 days	8.5 years	4-5 years	3 days	32 days	3-4 years	unknown

- Some of these chemicals are more potent than the others, but all of them have the similar effects

	PFBA (C4)	PFPeA (C5)	PFHxA (C6)	PFHpA (C7)	PFOA (C8)	PFNA (C9)	PFDA (C10)
Mouse	1.0	1.1	1.3	4.6	8.5	10.2	2.6
Humans	1.0	1.4	1.6	5.0	6.5	6.8	--

- Laboratory results suggest that PFAS effects are additive

Profiles of PFAS Toxicity and Adverse Health Effects

- Liver and Metabolic toxicity
 - *Mouse*: enlarged and fatty liver, decreased [serum cholesterol](#), triglycerides
 - *Humans*: increased [serum cholesterol](#), uric acid
- Reproductive and Developmental Toxicity
 - *Mouse*: neonatal mortality, [low birth weight](#), [growth deficits](#), [developmental delays](#)
 - *Humans*: preeclampsia, [low birth weight and small size](#), [delayed onset of puberty](#)
- Tumor Induction
 - *Mouse*: liver, pancreas and [testes](#)
 - *Humans*: kidney and [testes](#)
- Immunotoxicity
 - *Mouse*: atrophy of thymus and spleen, [suppressed immune responses](#)
 - *Humans*: [reduced immune responses to vaccines in children](#)
- Endocrine Disruption
 - *Mouse*: reduced serum thyroid hormones
 - *Humans*: slight elevation of serum thyroid hormones
- Neurotoxicity
 - *Mouse*: a few reports of neuronal deficits and behavioral abnormalities
 - *Humans*: some reports of learning disability

US EPA Regulatory Efforts

- 2001 Agreement with company to terminate PFOS production in the US
- 2006 Stewardship Agreement with 8 major US producers to phase out use and production of PFOA by end of 2015
- 2009 Provisional Health Advisory levels set for PFOA and PFOS in drinking water
- 2009 Action Plan on Long-Chain PFAS – prepared to exercise TSCA section 6 that provides the Agency authority to ban or restrict the manufacture, processing, and use of these chemicals
- 2013 - 2105 Unregulated contaminant monitoring rule (UCMR3) program – national survey of PFAS in delivered drinking water
- 2002, 2007, 2015 Significant New Use Rules (SNURs) put in place to prevent new uses of selected PFAS and to prevent the importation of articles containing some PFAS

International Regulatory Efforts

- 2008 European Food Safety Authority (EFSA) established provisional tolerable daily intake (pTDI) values for selected PFAS in food
- 2009 selected PFOS-related compounds included in the Stockholm Convention on Persistent Organic Pollutants
- 2009 the delegates at International Conference on Chemicals Management (ICCM2) agreed to consider the development of stewardship programs and regulatory approaches to reduce emissions and content of PFAS in products and to work toward their elimination
- 2012 Long-chain PFAS listed on the REACH Candidate List of Substances of Very High Concern (SVHC)
- 2014 International Agency for Research on Cancer (IARC) classified PFOA as possibly carcinogenic to humans

Future Perspectives

- Demand for PFAS performance chemicals increasing with a shift in production of “legacy” materials to the developing world (India, Poland, China, Russia)
- New generation of “replacement” PFAS now being produced in the industrialized world, but their identity and health effects are relatively unknown.
- Environmental and health effects research on “replacement” PFAS now underway – preliminary results suggest they are very similar to legacy compounds
- New research on human exposure of PFAS and their adverse health effects, as well as their ecological impacts will support risk assessment and regulatory decisions
- Virtually every person has PFAS in their blood – biomonitoring studies will inform the trends of change in the future regarding new and legacy chemicals

Questions?

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