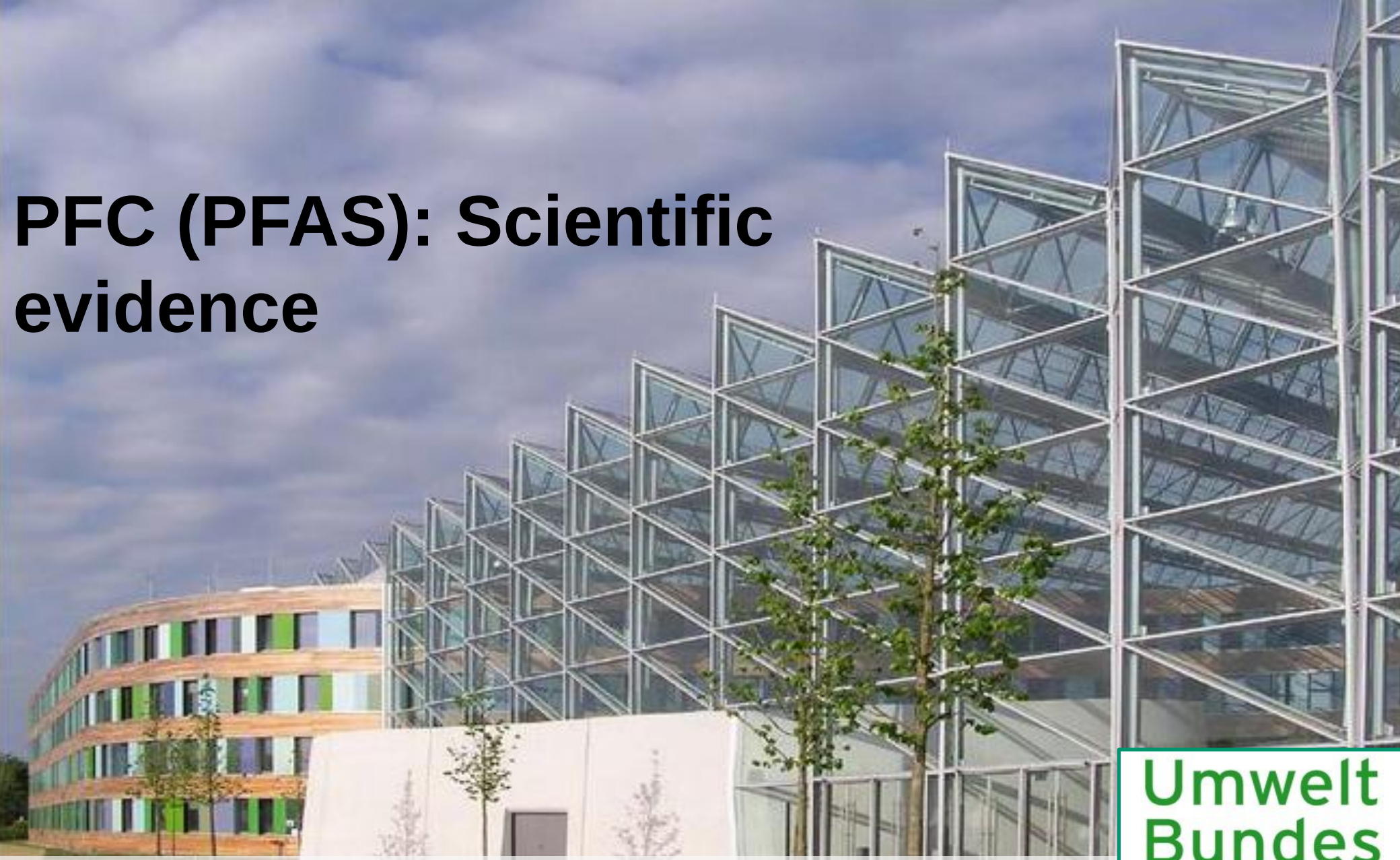
PFC (PFAS): Scientific evidence



Annegret Biegel-Engler
Federal Environment Agency, Germany

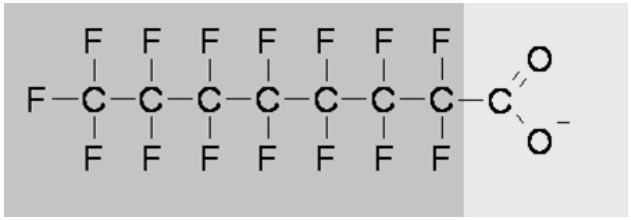
Umwelt Bundes Amt
For our Environment

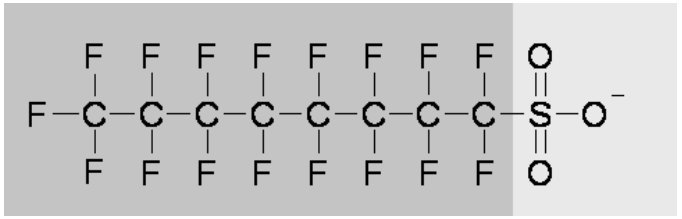
Scientific Evidence I - Content

- Introduction/definitions
- Sources and concerns
- Environmental fate
- Human exposure
- Conclusion

Definition - Short and long chain PFAS

Example	Short chain PFAS	Long chain PFAS
Perfluorinated carboxylic acids - **PFCA**	< 7 perfluorinated carbon atoms (e.g. PFBA)	7 and more perfluorinated carbon atoms (e.g. PFOA)
Perfluorinated sulfonic acids – **PFSA**	< 6 perfluorinated carbon atoms (e.g. PFBS)	6 and more perfluorinated carbon atoms (e.g. PFOS)





More information: OECD 2013: Synthesis Paper on per-and polyfluorinated chemicals (PFC)

Concerns of PFAS - especially long-chain PFCA and PFSA

- Findings and distribution in surface water
- Long-range transport and findings in remote areas
- Occurrence in food and in drinking water
- Occurrence in blood samples and breast milk of the general population
- Findings and accumulation in food webs and top predators
- Environmental persistence
- Toxicological profile (PFOA and PFOS Reprotoxic Cat. 1 B)

Precursors can be degraded to persistent PFCA and PFSA

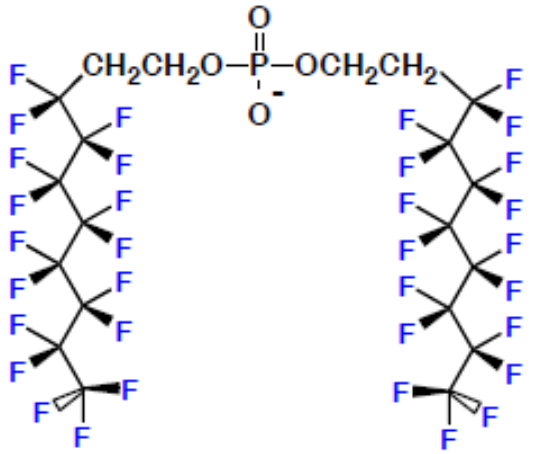
- Some examples:
  - Fluorotelomeralkohols (e.g. 8:2 FTOH)
  - Polyfluorinated phosphonic acids (PAPs)
  - Polyfluorinated iodides
  - …

Recent reviews:

Liu & Avendano, Environ Int, 2013; 61:98-114;

Butt, Muir, & Mabury, *Environ Toxicol Chem*. 2014; 33:243-67.

Young & Mabury, *Rev Environ Contam Toxicol.* 2010; 208:1-109

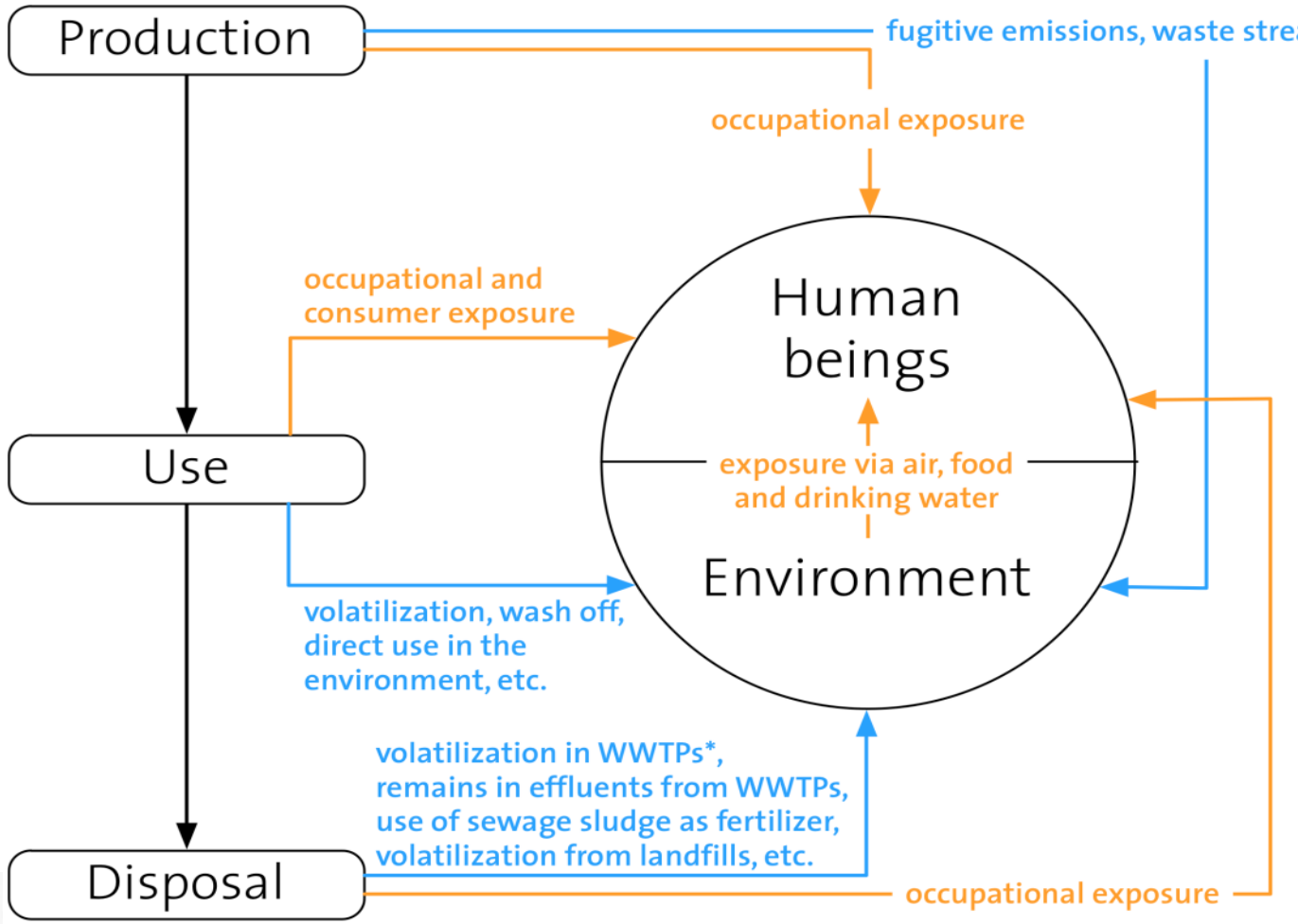


8:2 Di-PAPs

Environmental sources of PFOA and related substances: Examples

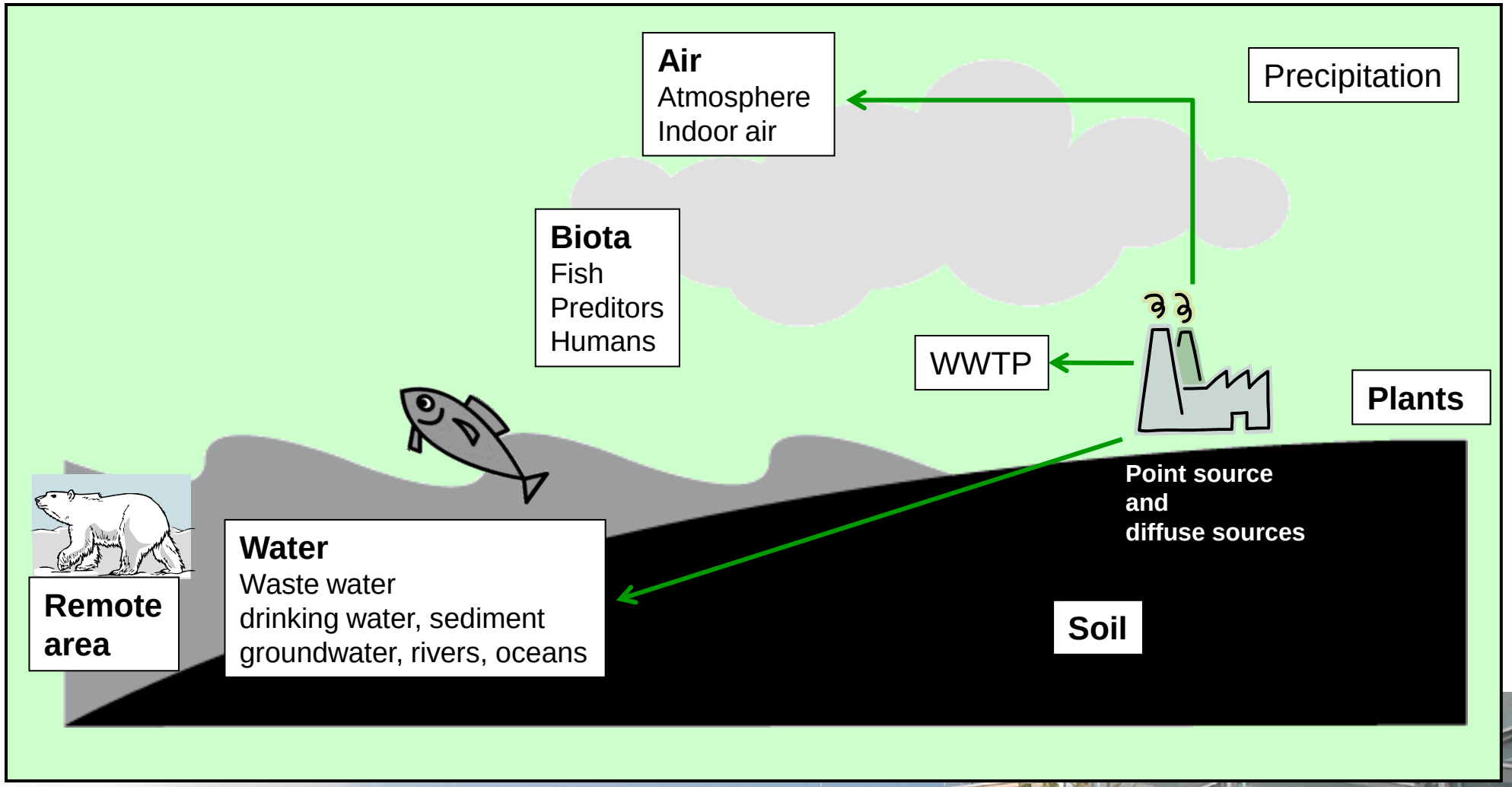
Direct sources	Indirect sources
•PFAS- manufacturing	•Release of residues in products
•Manufacturing of fluoropolymers	•Transformation of volatile precursors
•Residues from production and processing of fluorinated polymers	•Degradation of fluorinated polymers
•Downstream users (e.g. textile industry, electro-plating, paper industry)	•Sludge disposal in agriculture

Exposure routes of PFCA and PFSA and their precursors

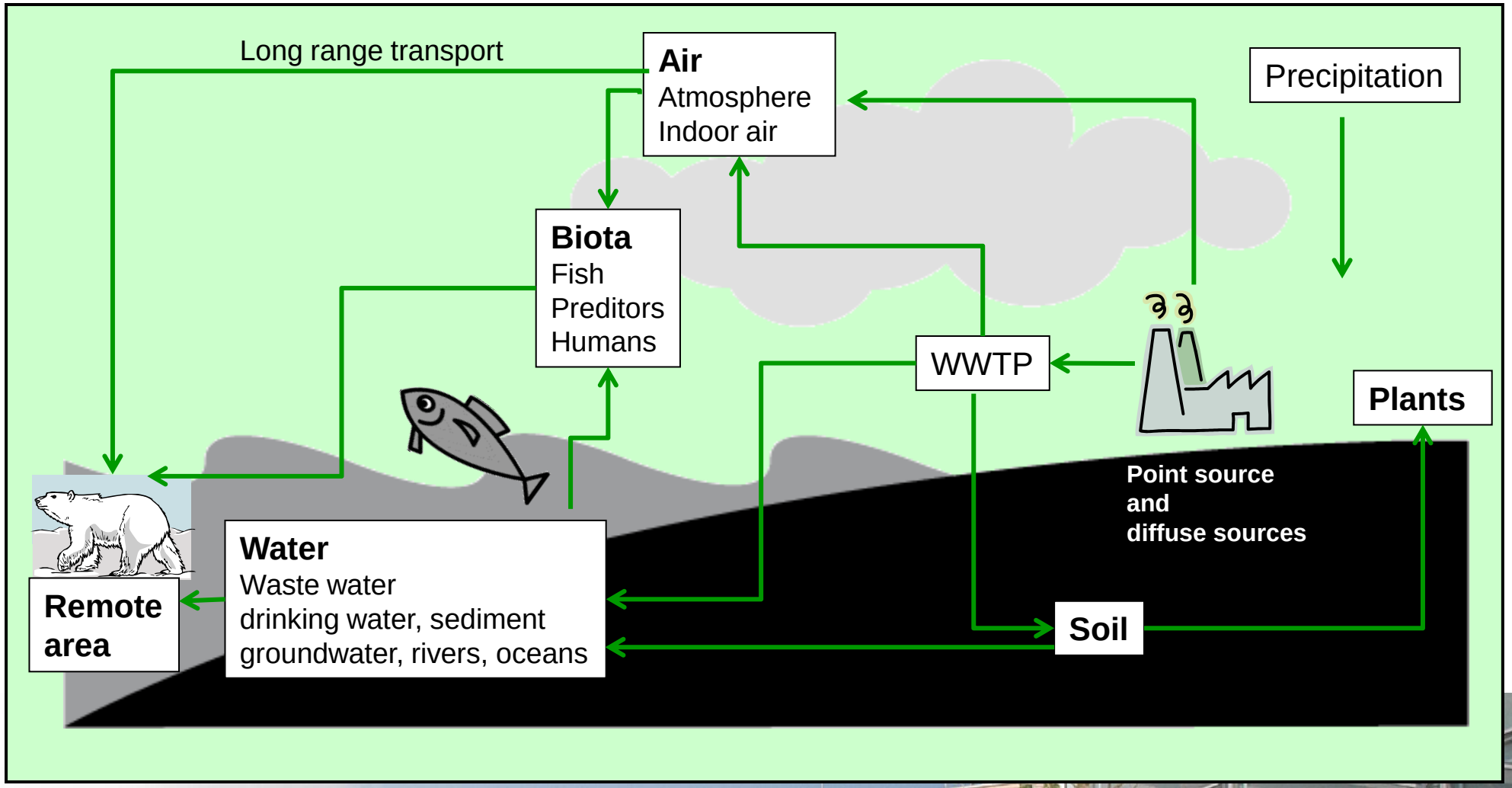


Source: OECD 2013: Synthesis Paper on per-and polyfluorinated chemicals (PFC)

PFAS: Distribution in the environment



PFAS: Distribution in the environment



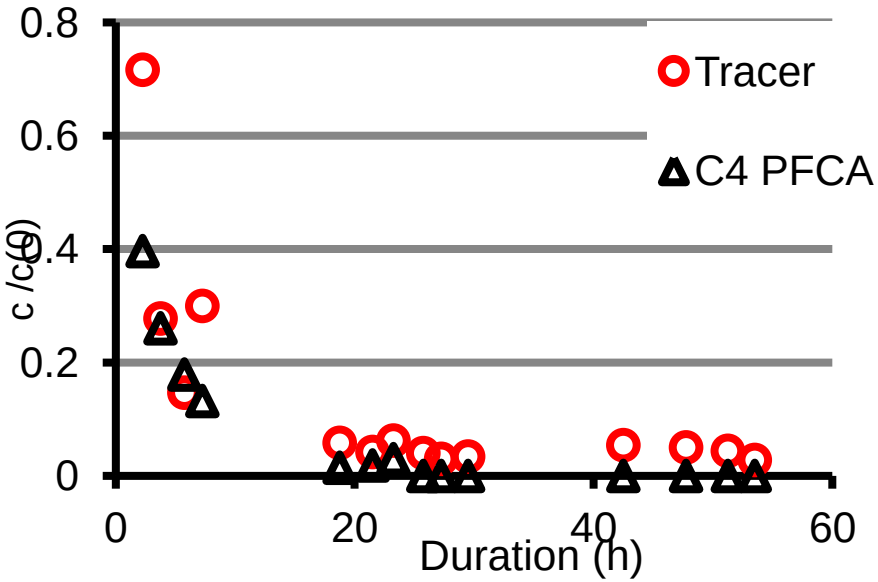
PFAS in surface water (ng/l)

		PFBS	PFHxS	PFOS	PFBA	PFhxA	PFOA	PFNA	
Streams of Lake Shihwa, 2004	South Korea	<0.5 - 24	1.94 - **84**	8.03 - **651**		0.77 - 27	5.21 - 62	0.83 - 7	Rostkowski et al., 2006,
West Coast, 2009	South Korea	<0.2-16	<0.2-8.7	0.35-47			0.54-31	<0.2-5.9	Naile et al., 2010,
River Xi, Fuxin, 2009	China	7-**445**	0.15-0.58	0.28-0.54			27 - **668**	0.43-16	Bao et al. 2011,
Liaoning , 2010	China		nd - 2.3	nd - 31			2.6 – 82	nd - 14	Wang et al., 2012
Rivers, 2010	Japan		nd - 8.4	nd - 97	<1.5 - 18	nd - **16000**	<1.5 - **360**	nd - 39	Takamine et al., 2014,
Tokyo Bay, 2004	Japan			13-25			154-192		Yamashita et al., 2004,
Rivers, 2008	Taiwan			49 – **5,440**			11 - **310**		Lin et al., 2009
Elbe, 2007	Germany	3.49-5.27	0.32-0.5	4.1 -6.2	nd - 0.4	1.66-2.56	4.36-4.81	0.69-1.16	Ahrens et al. 2010.
Baltic Sea, 2007	Baltic Sea	0.26-0.88	nd-0.61	nd-0.35	nd-0.44	0.12-0.27	0.25 – 4.55	0.1-0.42	Ahrens et al. 2010.
Steinbecke, 2005	Germany						**33,900**		Skutlarek et al. 2006.
Greenland Sea; 2007-2010		<0.001-0.02	nd-0.04	<0.1 - 0.16		<0.003 - 0.08	0.004 – 0.21	<0.003 - 0.1	Zhao et al. 2012.

Short chain PFAS: Mobility in soil and sediment

- (almost) no retardation of short chain PFAS in soil and sediment
- Findings in surface waters, ground water, drinking water and tap water

→ potential threat for drinking water

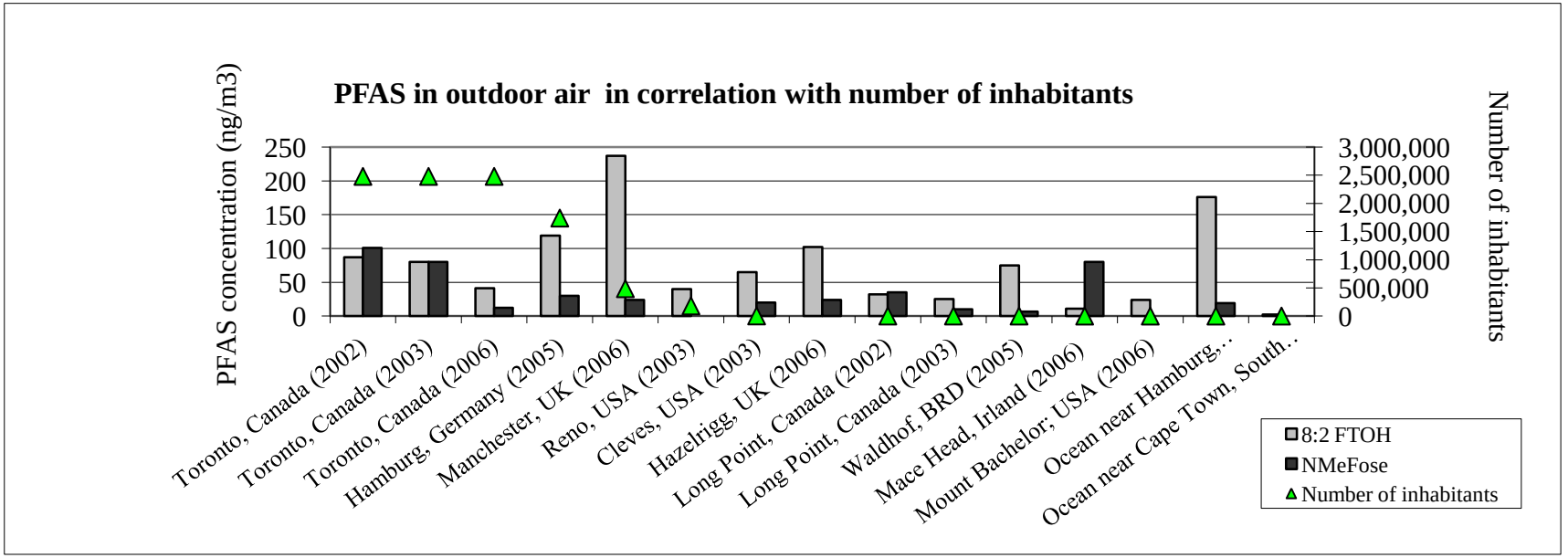


Vierke, Möller, & Klitzke, *Environ Pollut*, 2014; 187,7-13.

Gellrich, Stahl & Knepper *Chemosphere*, Behavior of perfluorinated compounds in soils during leaching experiments 2012; 87,1052–1056

PFAS in air

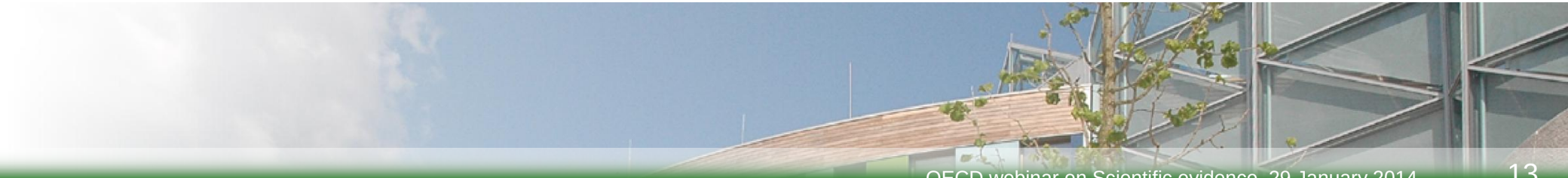
- Particle bound in dust
- Volatile PFAS in air phase
- Concentrations in indoor air 30 to 600 times higher compared with outdoor air
- High values found in outdoor shops, offices, carpet shops, homes, etc.



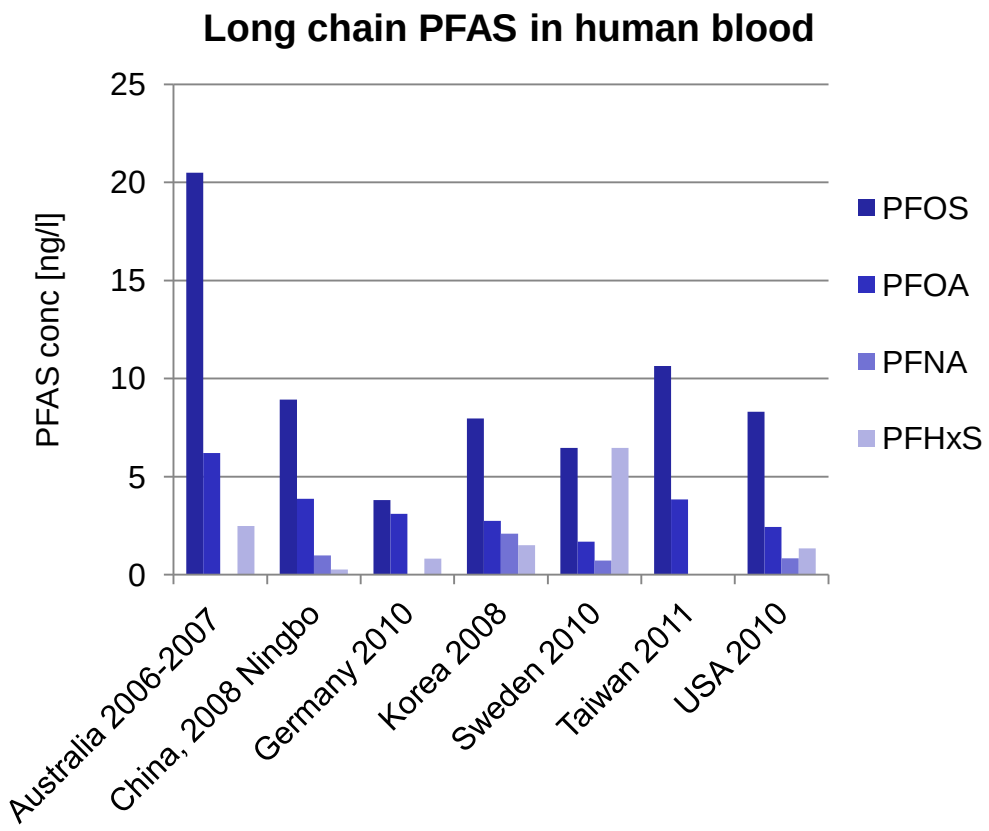
Fraser et al., Environ Int. 2013;60:128-36
Schlummer et al., *Environ Int* 2013;57-58 42–49
Takahashi et al., Chemosphere. 2013; 90(5):1672-7
Cai et al., Chemosphere. 2012; 87(9):989-97
Haug et al., Environ Sci Technol. 2011;45(19):7991-8
Shoeib et al, Environ. Sci. Technol. 2006, 40, 7577-7583

Long chain PFAS in biota

Animal	PFOS [µg/kg]	PFOA [µg/kg]	Source
Polar bears (2006)	2108 – 3868	11.8 - 17.6	Dietz et al., 2008
Seals, Arctic (2005)	8.0 - 44.1	0.96 – 1.01	Butt et al., 2007
Seals, Lake Baikal	<0.55 – 18	<1.1	Ishibashi et al., 2008
Eel, European rivers	up to 498	up to 23	Greenpeace 2006



Findings in humans – human blood

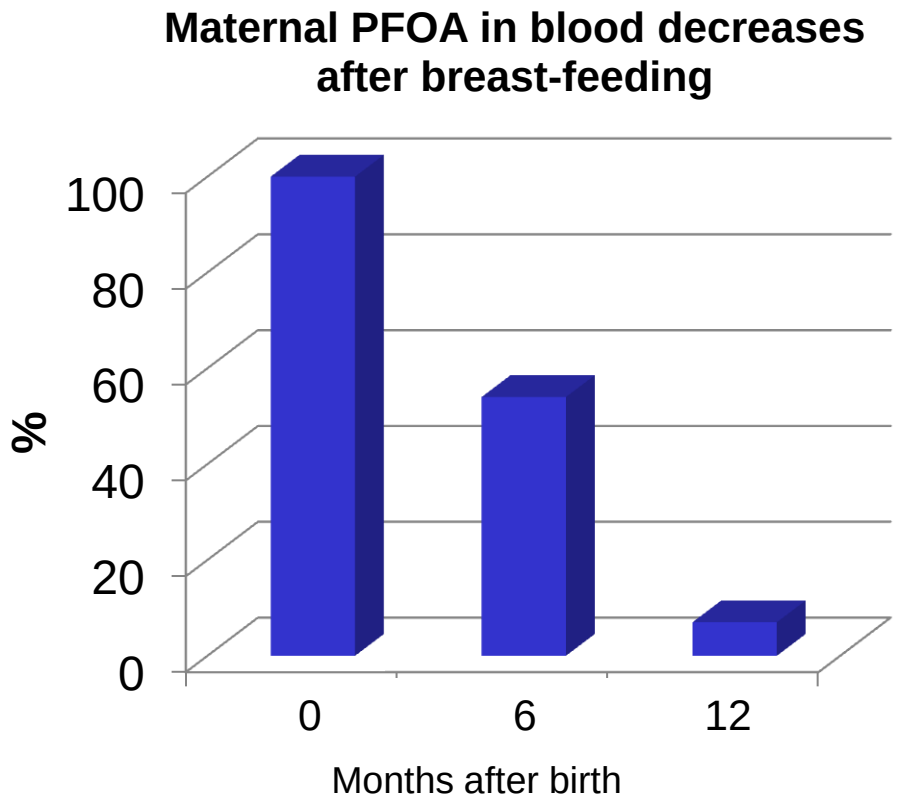


- ✓ Long chain PFAS are present in the general population worldwide
- ✓ Intake: indoor and outdoor air and aerosols, drinking water, dust, food
- ✓ Blood levels increase due to occupational exposure (e.g. in PFAS-related production sites)

Toms et al., 2009
Liu et al., 2009
Guo et al., 2011
Pan et al., 2010
Schroeter-Kermani 2013
Ji et al., 2012
Glynn et al., 2012
Hsu et al., 2013
Olsen et al., 2012

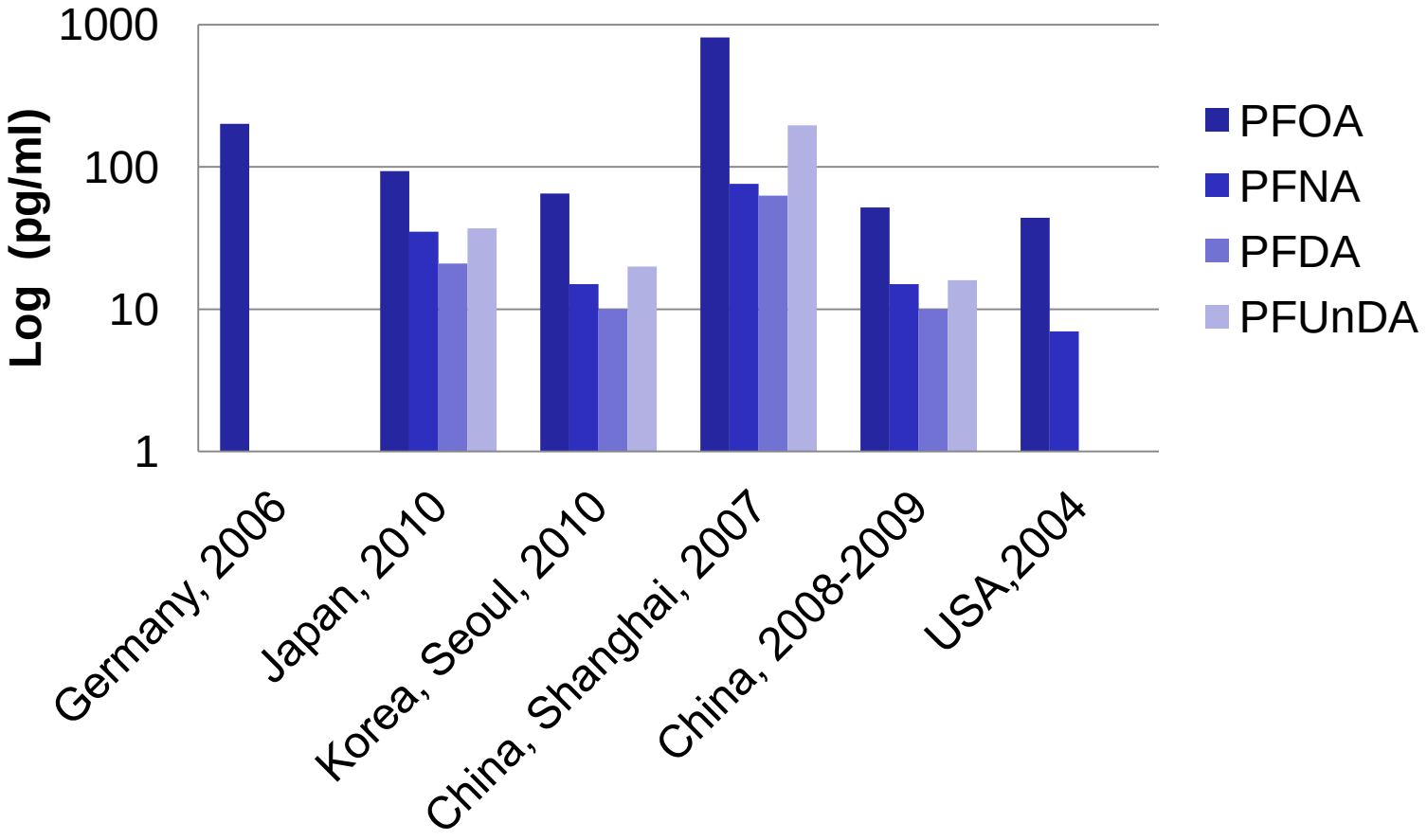
Mothers transfer long chain PFAS to their infants

- PFAS present in maternal blood may pass through the placenta and reach the foetus
- PFOA levels in blood decrease during breastfeeding
- Mothers build up their original PFOA blood levels after the breast-feeding period



Brantsaeter et al. 2013
Thomsen et al., 2010
Fromme et al., 2010
Haug et al., 2011

Long chain PFAS in breast milk



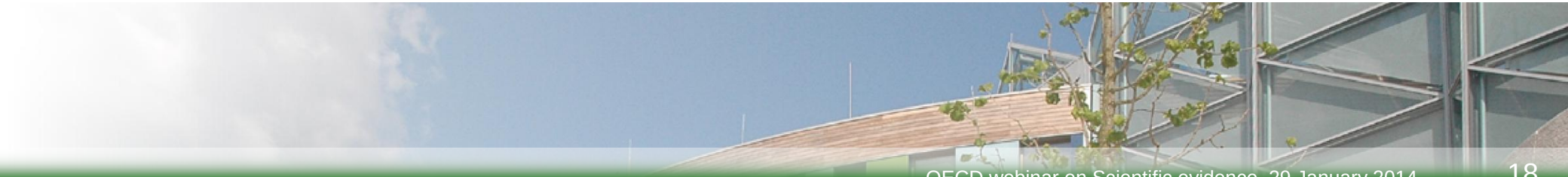
Toxicity of long chain PFAS - C8 Science panel

- Exposure and health studies in the Mid-Ohio Valley communities, which had been potentially affected by the releases of PFOA (or C8) emitted since the 1950s from the Washington Works plant in Parkersburg, West Virginia
- Period: 2005-2013
- Assessed the links between PFOA exposure and a number of diseases.
- For six disease categories, the Science Panel concluded that there was a Probable Link to PFOA exposure: diagnosed high cholesterol, ulcerative colitis, thyroid disease, testicular cancer, kidney cancer, and pregnancy-induced hypertension

http://www.c8sciencepanel.org/

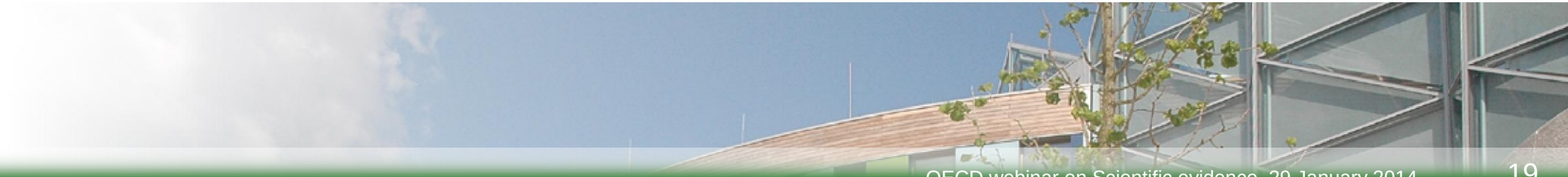
Long chain perfluorinated alkyl acids: Properties of very high concern

- Persistent
- Bioaccumulative
- Some are toxic – e.g. PFOA
  - Repr 1B (H360D); may damage the unborn child
  - STOT RE 1 (H372 (liver); Causes damage to liver through prolonged or repeated exposure



Conclusion

- PFAS are ubiquitously present in all environmental compartment
  - due to numerous sources and their environmental behaviour (long range transport, persistency, bioaccumulation,...)
- Long chain PFAS: Combination of persistence and bioaccumulation is of very high concern since long term effects cannot be predicted (some PFAS are classified as being toxic)
- Long chain PFAS are present in human blood and breast milk of the general population
- Alternatives are available
- Need for global action



Umwelt Bundes Amt
Für Mensch und Umwelt

Thanks!

Dr. Annegret Biegel-Engler

Annegret.Biegel-Engler@uba.de

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