PFAS risk assessment on fire fighting training sites

RemTech Europe

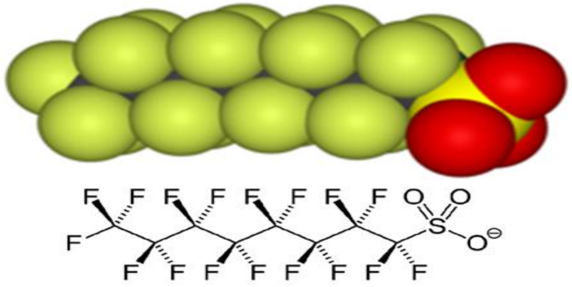
20.9.2019, Ferrara

Jussi Reinikainen

jussi.reinikainen@env.fi

Per- and polyfluoroalkyl substances (PFAS)

- Used in many industrial and commercial applications since 1950s
  - ❑ Fire fighting foams (AFFF), electro-plating, cosmetics, coating additives etc.
- Exceptional chemical properties
  - ❑ C-F bond very strong against biological, chemical and thermal degradation
  - ❑ Persistent, surface active and both water- and oil-repellent
- Ubiquitous in all the environmental media and biota
  - ❑ Many PFAS also toxic at very low exposure levels
  - ❑ Precursors may degrade to persistent PFAAs
- PFOS and PFOA most studied and regulated
  - ❑ Use restrictions in REACH and POP regulations
- No data available on most PFAS
  - ❑ Around 4700 individual PFAS known to exist today



Risk assessment for PFAS – existing thresholds

- Environmental quality standards (surface water) for PFOS and its precursors
  - EQS-biota (perch): **9,1 µg/kg$_{fw}$** -> 0,11 µg/kg$_{fw}$
  - MAC-EQS, 36 µg/l (inland waters); 7,2 µg/l (other waters)
  - AA-EQS: 0,65 ng/l, NOT applied in FIN -> 0,0078 ng/l

<< normal ”background” concentrations

- Health-based reference values (TDI)
  - 150 ng/kg$_{bw}$-d (PFOS), EFSA 2008
  - 1500 ng/kg$_{bw}$-d (PFOA), EFSA 2008
  - **1,8 ng/kg$_{bw}$-d (PFOS), EFSA 2018**
  - **0,86 ng/kg$_{bw}$-d (PFOA), EFSA 2018**

⇒

BFC = 2800 l/kg
BMF = 5
IR = 115 g/d
BW = 70 kg
10 % allocation

⇒

EQS-biota and AA-EQS

- National proposal for an environmental quality standard (groundwater)
  - 0,1 µg/l for single PFAS
  - 0,5 µg/l for sum of PFAS

For assessing groundwater quality on a GW body level

- EU proposal for a drinking water standard (EU Drinking Water Directive)
  - 0,1 µg/l for single PFAS (long chain PFAS)
  - 0,5 µg/l for sum of PFAS

→ **Regulatory objectives and derivation basis of the thresholds need to be considered when applying them in CLM (i.e. site-specific decision making)**

Thresholds for assessing soil/GW contamination...?

- Generic concentration thresholds has NOT been (and won't be) given

- Why?
  - FIN policy approach strives for promoting realistic and justified, site-specific risk-based decision making
  - Direct use of generic values often neglects actual risks (and may even underestimate them)
  - Concentration -based decision making often promotes unnecessary or unsustainable remediation
  - Assessment of risks due to contaminant migration should always be fluxed-based
  - Generic soil/GW thresholds for remediation of PFAS particularly questionable as PFAS are ubiquitous and often cannot be permanently removed from the environment in a practical and cost-efficient manner

Fire fighting foams and training sites

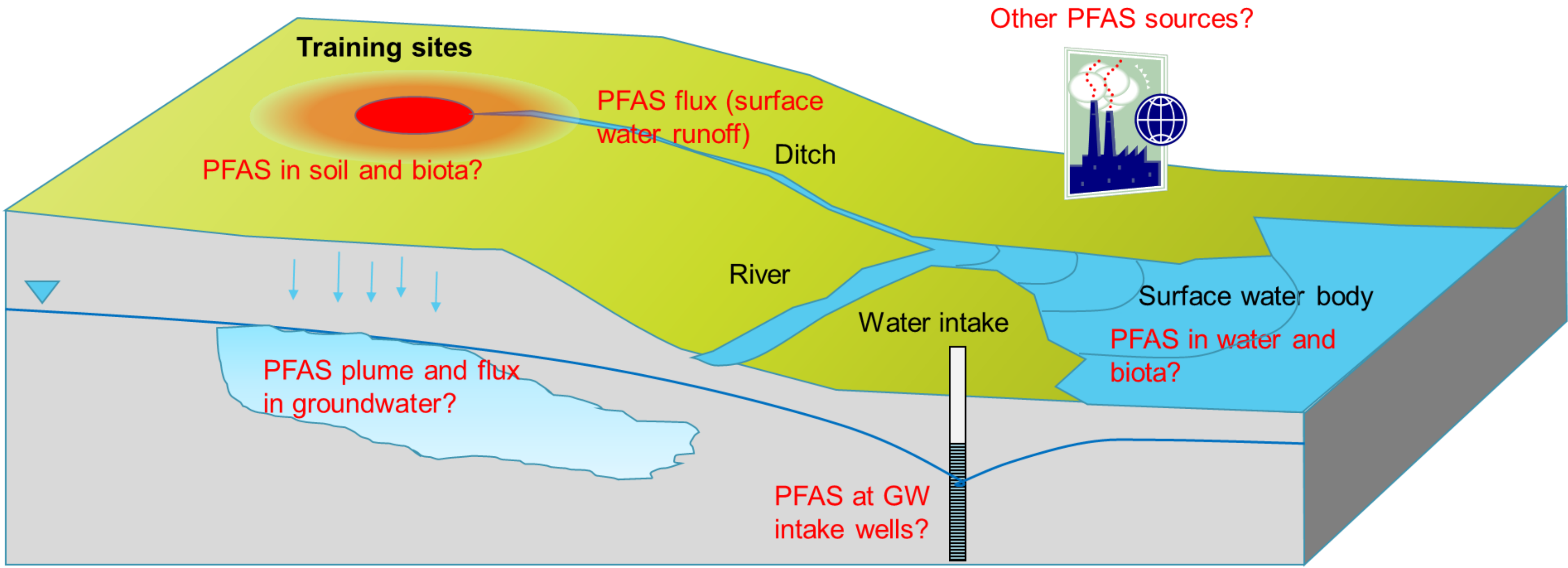
- Using PFOS-containing foams was prohibited in the EU in 2011 (PFOA 2020 ->)
  - PFOS (and PFOA) often substituted with short chain PFAS or PFAA precursors whose properties not well known
  - Also PFAS content in the foams variable and not known
- In Finland, awareness raising in early 2010’s due to national and international findings
  - E.g. drinking water contamination in Sweden and national studies by Finavia (now using only water in FF training)
  - → Fire fighting foams and training sites considered as major problems
- Several screening studies carried out to get an overview of the situation
  - Targeted at known sources and ”risk locations” (e.g. upgradient of municipal water works)
  - → PFAS is everywhere, but in most cases situation isn’t alarming
  - → However, more information needed!

FIN EPA project on FF training sites

- Targeted at four identified ”risk sites”
  - 3 FF training sites and 1 industrial site (including 1 remediated FF training site)
- Objectives
  - To assess site-specific risks of PFAS and their management needs on the selected sites
  - To increase generic knowledge-base on PFAS contamination and risks due to use of AFFF
  - To give recommendations and guidance for site characterization, risk assessment and laboratory measurements of PFAS
- Site assessment by KISS
  - Keep It Simple Stupid
  - Measurements for 23 PFAS (usual PFAAs and some precursors)
  - Data from previous screening studies and monitoring programmes also applied
  - Data on PFOS used to determine risks

Vertailuarvo, PFOS	
AA-EQS, sisämaan pintavedet	0,65 ng/l
AA-EQS, muut pintavedet	0,13 ng/l
MAC-EQS, sisämaan pintavedet	36 µg/l
MAC-EQS, muut pintavedet	7,2 µg/l
EQS-eliöstö, pintavedet	9,1 µg/kg tp.
HC5, vesieliöt HC1, vesieliöt	3 300 (90 % lv. 420–13 000) ng/l 460 (90 lv. 32–2 600) ng/l
HC5, maaperäeliöt	3,2 (90 % lv. 0,44–9,8) mg/kg
HC5, nisäkkäiden ja lintujen ravinto HC1, nisäkkäiden ja lintujen ravinto	2,6 (90 % lv. 1,2–4,5) mg/kg_{diet} 1,2 (90 % lv. 0,43–2,4) mg/kg_{diet}
Pohja- ja juomavesi	100 ng/l, PFOS (ja muut yksit-täiset PFAS-yhdisteet) 500 ng/l, PFAS-summapitoisuus
TDI	150 ng/kg-vrk (EFSA 2008) 1,8 ng/kg-vrk (EFSA 2018)

Generic CSM for the assessment

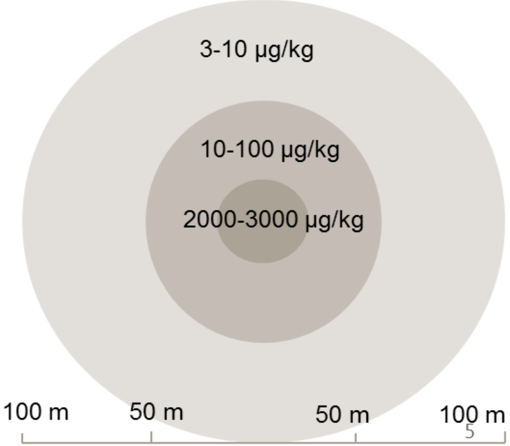


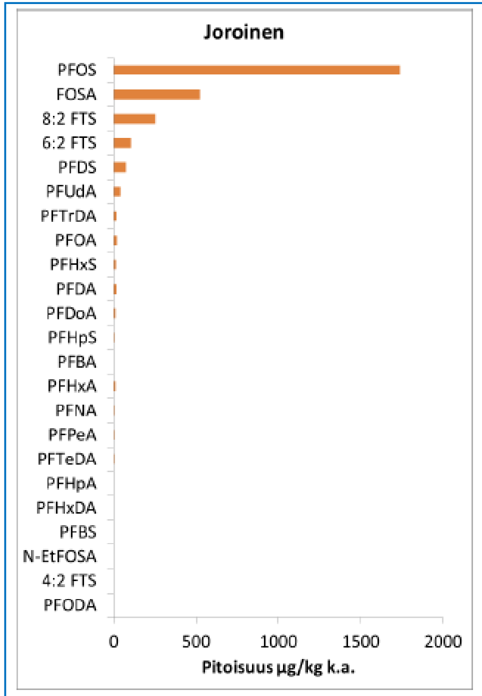
Results for PFAS in soil

- Higher PFAS concentrations in top soil cover only small surface area
  - ❑ Sampling by multi-increment approach (representative average concentration)
- PFAS often the most abundant substance
  - ❑ Even on sites, where PFOS-foams haven’t been used for years
  - ❑ Amount of PFAA precursors can be high and is likely increasing
- Direct exposure to PFAS in soil not critical
  - ❑ Including secondary poisoning (bioaccumulation on soil invertebrates)

→ **Most significant risks concern surface water and groundwater emissions – off site migration**

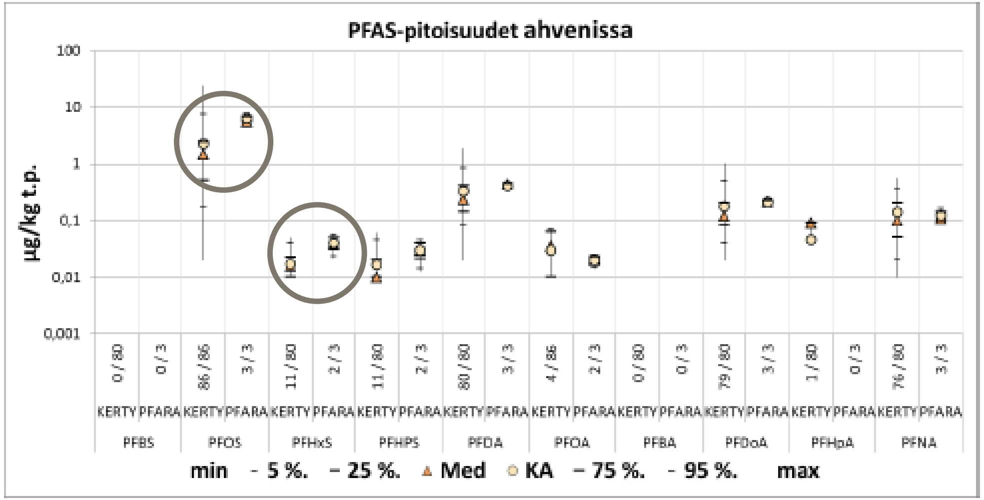
- ❑ Risk assessment needs to focus on transport of PFAS and its associated impacts on recipient waters

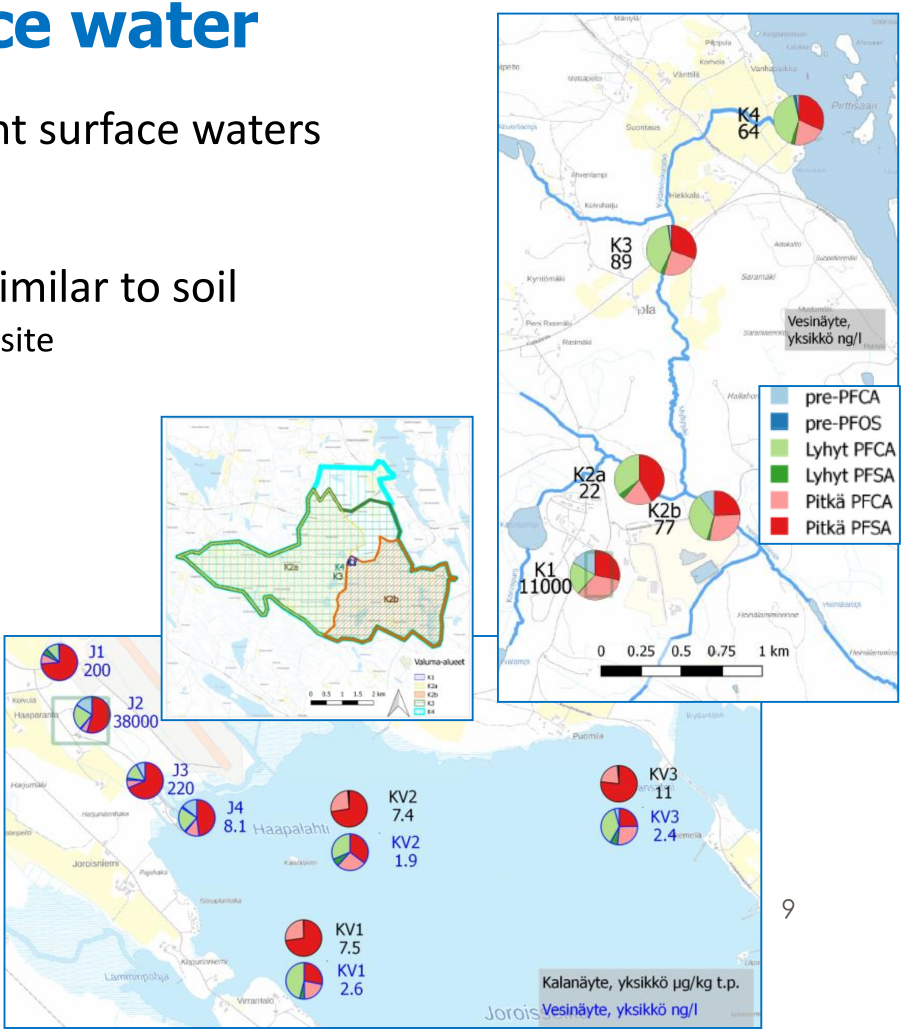




Results for PFAS in surface water

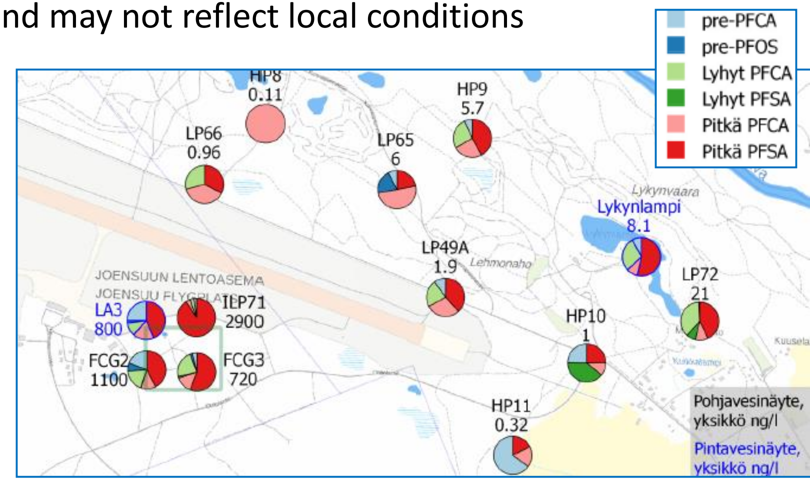
- PFAS emissions affect water quality in recipient surface waters
  - Travel distances can be several kms
  - Flux-based assessment needed (catchment areas)
- PFAS concentration profiles in surface water similar to soil
  - Occurence of different PFAS varies depending on the site
- Elevated concentrations also in fish
  - Especially for long chain PFSAs
  - EQS biota for PFOS may be exceeded





Results for PFAS in groundwater

- Contribution of short chain PFAS greater than in soil or surface water
  - Especially further away from source areas
- Concentrations may reduce significantly outside the source area
  - Plume length is not necessarily that great
- Plume characterization and assessment of PFAS transport may be difficult
  - Vertical, horizontal and temporal variation in concentrations
  - Other PFAS sources exist and low concentrations complicate interpretation far from the source
  - Groundwater recharge conditions affect vertical distribution
  - Literature data for transport assessment (e.g. Kd) varies and may not reflect local conditions
- GW intake at our sudy site not at risk (for now)
  - Based on plume characterization and simple transport and mass-balance calculations
  - 3D flow and tranport model in preparation



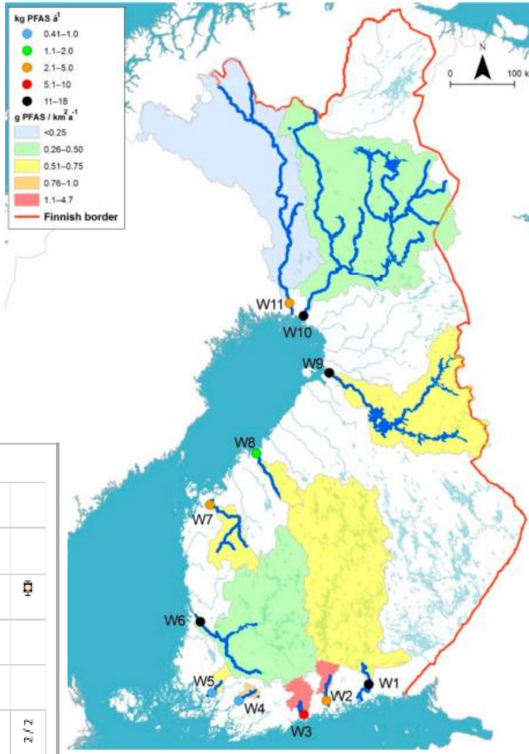
Results from industrial site – oil refinery

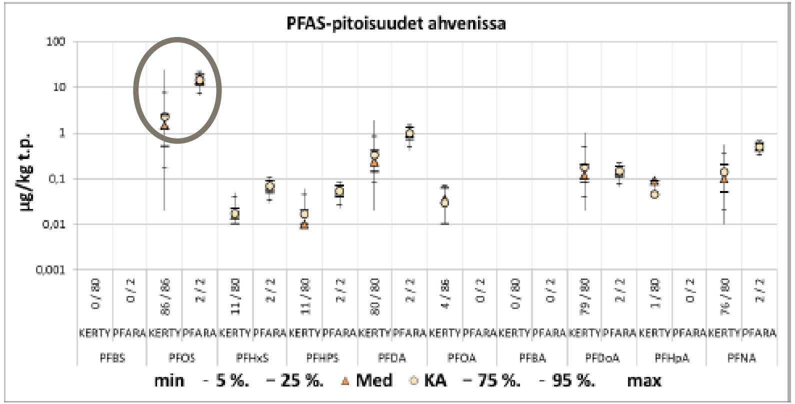
- Industrial mega site next to Baltic Sea with several potential PFAS sources
  - Including waste water treatment plant and one remedia
- Complex but well defined hydrogeology
  - 3 discharge points (surface water) with continuous mon
  - Sea water tunnel circulating cooling water (1,1 Mm^3 /a)
- First investigations targeted at former FF trainin
  - Remediated (excavation) in 2016 -> 60 kg of PFOS remo
  - PFAS concentrations in water near the source haven't re
  - Biggest PFAS load on discharge point 1 (no hyd. connect

- Huge tank fire (isohexane) in 1989
  - 260 m^3 of PFAS-foams used for fire extinction
  - Potential release of PFOS to soil (based on conc. in old foams) even 2000 kg
  - Upgradient of discharge point 1 -> major PFAS source

Results from industrial site – oil refinery

- PFAS emissions to the Baltic sea substantial
  - <u>PFOS</u> emissions more than in any studied river catchment area in Finland
  - Emissions mostly from AFFF in soil (especially the tank fire)
  - AA-EQS for PFOS exceeded on wide area (average 2 ng/l)
  - PFOS concentrations in fish (22 µg/kg) exceeding the EQS-biota (9,2 µg/kg)
- Risk/emission reduction needed
  - Additional site investigations on-going to further delineate PFAS sources and transport routes, and hence to target emission reduction measures
  - Health risk assessment regarding the consumption of fish started in the health agency; sea area used for private and professional fishing





Health risks - dietary exposure in Europe

EFSA Journal 16(12) 2018

- PFOS: 1,3-21 ng/kg_{bw}-d
- PFOA: 1,5-18,3 ng/kg_{bw}-d

>

TDI_{PFOS}: 1,8 ng/kg_{bw}-d
TDI_{PFOA}: 0,8 ng/kg_{bw}-d

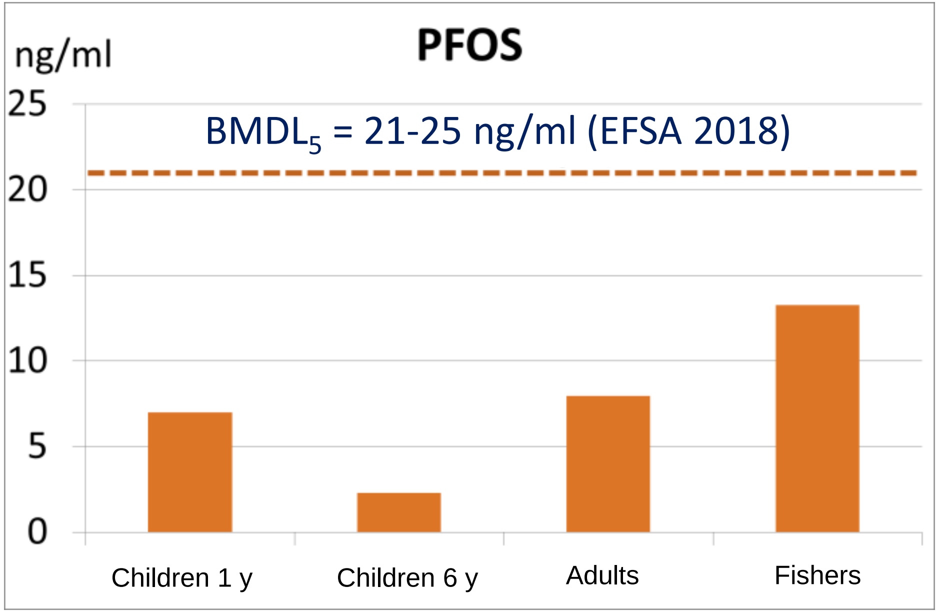
Based on epidemiolgical studies with critical endpoints ($BMDL_5$) of increased serum cholesterol and decreased antibody response after vaccination

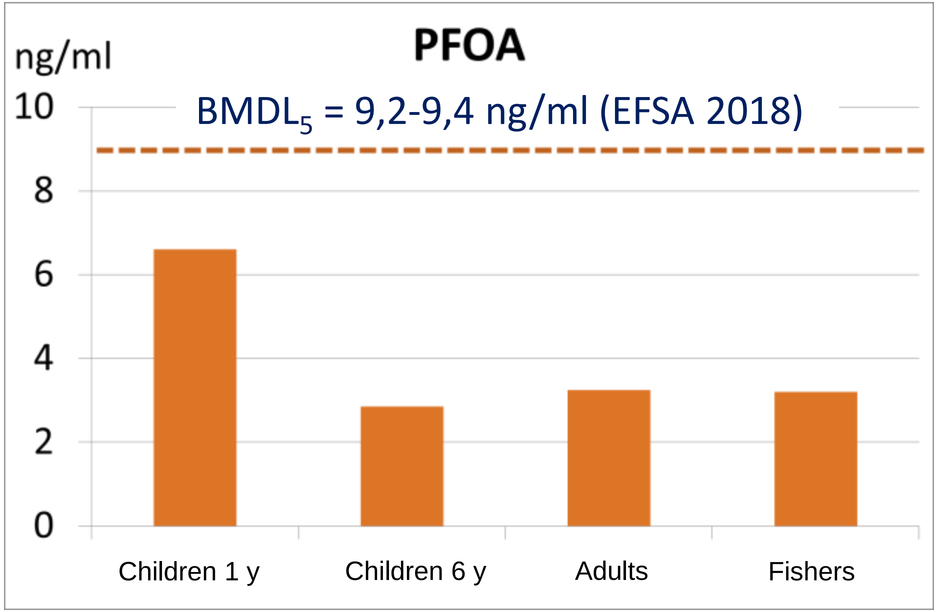
→ **Challenges for risk management, policymaking and communication**

→ **Note: EFSA assessment (2018) criticized by several member states**

Human exposure FIN – concentrations in blood

- Based on the Finnish public health agency, only substantial fish consumption may result in exceeding the threshold, and even then the benefits of eating fish are likely to out-weight the risks
  - Comprehensive health risk assessment regarding the consumption of fish (including risk-benefit analysis) started in the health agency





Finnish Insitute for Health and Welfare, 2019

Taking the Finnish dietary habits into account; how worried do we need to be about increased cholesterol levels due to eating fish...?

Marja Airio/Lehtikuva

Conclusions

- Results from FIN site studies similar to international findings, e.g.
  - PFAS fate and transport; long vs. vs. short chain compounds
  - PFOS still major risk driver
  - Amount of precursors can be high and likely increasing in the future
- Off-site migration defines the risks – groundwater and surface water
  - Potential long-term effects (bioaccumulation and secondary poisoning) and eating fish
  - Using groundwater as drinking water (if intake wells downgradient and close enough to source areas)
  - Even single sites (FF training or fires) can have great impacts
  - However, exposure in most cases (in FIN) low; no need for (immediate) risk reduction

GRAZIE MILLE!