Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

Indoor environment sampling strategies and preliminary results - the A-TEAM project

Juan Antonio Padilla Sanchez, NIPH

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

OUTLINE

- Introduction
- A-TEAM indoor environment sampling strategies
    i. Home and personal air
    ii. Settle, floor and VCB dust
    iii. Hand wipes
- PFASs sample pre-treatment and analysis
    i. Indoor air
    ii. Indoor dust
- Results and discussion of PFASs in indoor environment
    i. Home air
    ii. Personal Air
    iii. Home vs personal air
    iv. Exposure assesment to PFOA
- A-TEAM Future Tasks
- Questions

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

Introduction

- Consummer products used in our daily life are made with chemicals providing properties to this products.





Emerging Brominated Flame Retardants (EBFRs) Organophosphate Esters (OPEs)
Phthalate Esters (PEs) Per- and polyfluorinated Alkyl Substances (PFASs)

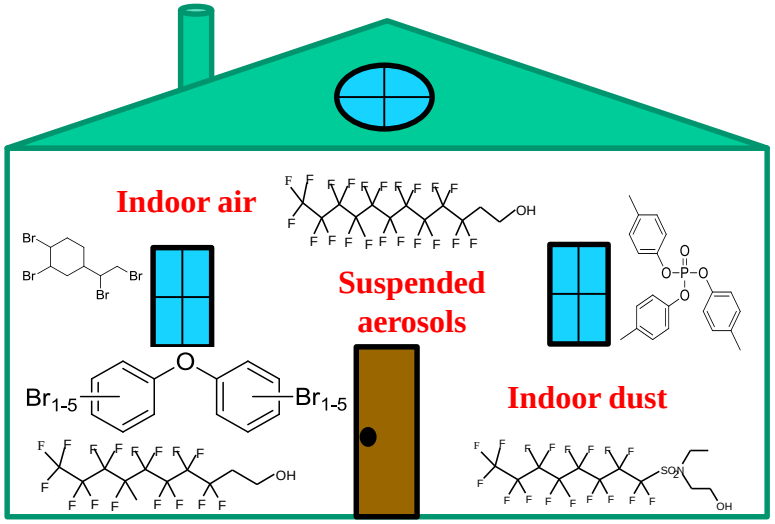
«Consumer Chemicals»

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

Introduction

Leaching



Main body burden contributors

- Dust ingestion
- Air inhalation
- Dermal absorption

Persistent Organic Pollutants (POPs) and their precursors

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

Introduction

- Several approaches have been carried out aroung the world in order to study the occurence of those consumer chemicals in indoor environments and human exposure.

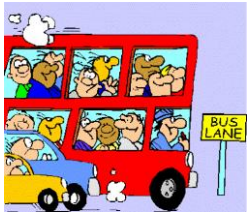
Belgium Canada Sweden Norway China United States Japan United Kingdom Germany South Korea

Homes Offices Cars Shops Work places Kindergardens

- However, contamination pathways contributing to human body burden of EBFRs, PFASs, OPEs and PEs still remain unclear

Home dust and air?
Settle or floor dust?
Living room air?

Indoor air at workplace?



Indoor air in transport?

Indoor air in sport centers?

Dust ingestion throug hand wipes?

Important information gap between external and internal dose of pollutants

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

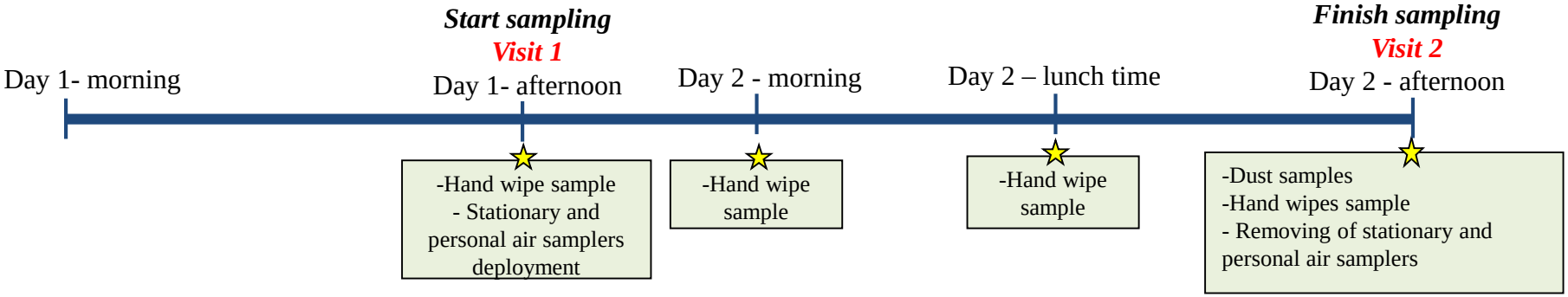
Introduction

- At this point A-TEAM came up

Network: University of Antwerp (UA), Stockholm University (SU), Swedish Emvironmental Institute (IVL), Norwegian Institute of Public Health (NIPH), University of Amsterdam (VU), University of Reading (URead), University of Birmingham (UoB).

Objective: Try to minimize this information gap investigating the contamination pathways to EBFRs, OPEs, PFASs and Pes in indoor environments

- 61 houses were visited in Oslo area



Air

Personal

Home

Home air: 281 samples
Personal air: 61 samples

Hand wipes

Hand wipes: 281 samples

Indoor Dust

Settle

Floor

VC Bag

Settled dust: 61 samples
Floor dust: 61 samples

VC bag dust: 58 samples

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

OUTLINE

- Introduction
- A-TEAM indoor environment sampling strategies
  i. Home and personal air
  ii. Settle, floor and VCB dust
  iii. Hand wipes
- PFASs sample pre-treatment and analysis
  i. Indoor air
  ii. Indoor dust
- Results and discussion of PFASs in indoor environment
  i. Home air
  ii. Personal Air
  iii. Home vs personal air
  iv. Exposure assesment to PFOA
- A-TEAM Future Tasks
- Questions

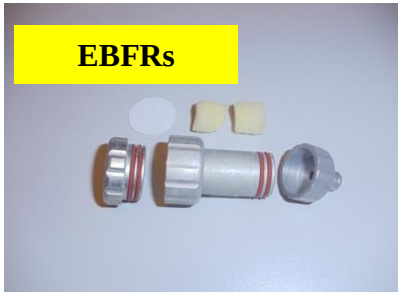
Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

Indoor environment sampling strategies: Home and personal air

HOME AIR

EBFRs



Sorbent: 4 sampling trains (2 PUFs + 1 GFF each)
Pump: SKC Leland Legacy
Collection time : 24 h
Flow: 12 L min^{-1}
Volume air: 17,28 m^3

(*Thuresson et al. 2012*)

61 samples

SU

PFASs

Sorbent: 4 ENV+ (0,2 g 6 mL)
Pump: SKC Leland Legacy
Collection time : 24 h
Flow: 5 L min^{-1}
Volume air: 7,2 m^3

(*Nilsson et al. 2013*)

61 samples

NIPH

OPEs+PEs

Sorbent: 4 ENV+ (0,2 g 6 mL)
Pump: SKC Leland Legacy
Collection time : 24 h
Flow: 5 L min^{-1}
Volume air: 7,2 m^3

(*Staaf & Östman et al. 2005*)

61 samples

IVL

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

Indoor environment sampling strategies: Home and personal air

PERSONAL AIR

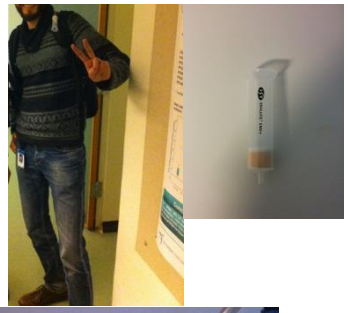
EBFRs

Sorbent: 1 sampling train (2 PUFs + 1 GFF)
Pump: SKC personal pump
Collection time : 24 h
Flow: 1 L min^{-1}
Volume air: 1,44 m^3

15 samples

SU

PFASs



Sorbent: 1 ENV+ (1 g 25 mL)
Pump: SKC personal pump
Collection time : 24 h
Flow: 1 L min^{-1}
Volume air: 1,44 m^3

15 samples

NIPH

OPEs+PEs

Sorbent: 1 ENV+ (1 g 25 mL)
Pump: SKC personal pump
Collection time : 24 h
Flow: 1 L min^{-1}
Volume air: 1,44 m^3

15 + 15 samples

IVL

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

Indoor environment sampling strategies: Settle, Floor and VCB dust

SETTLE




61 samples

FLOOR




61 samples

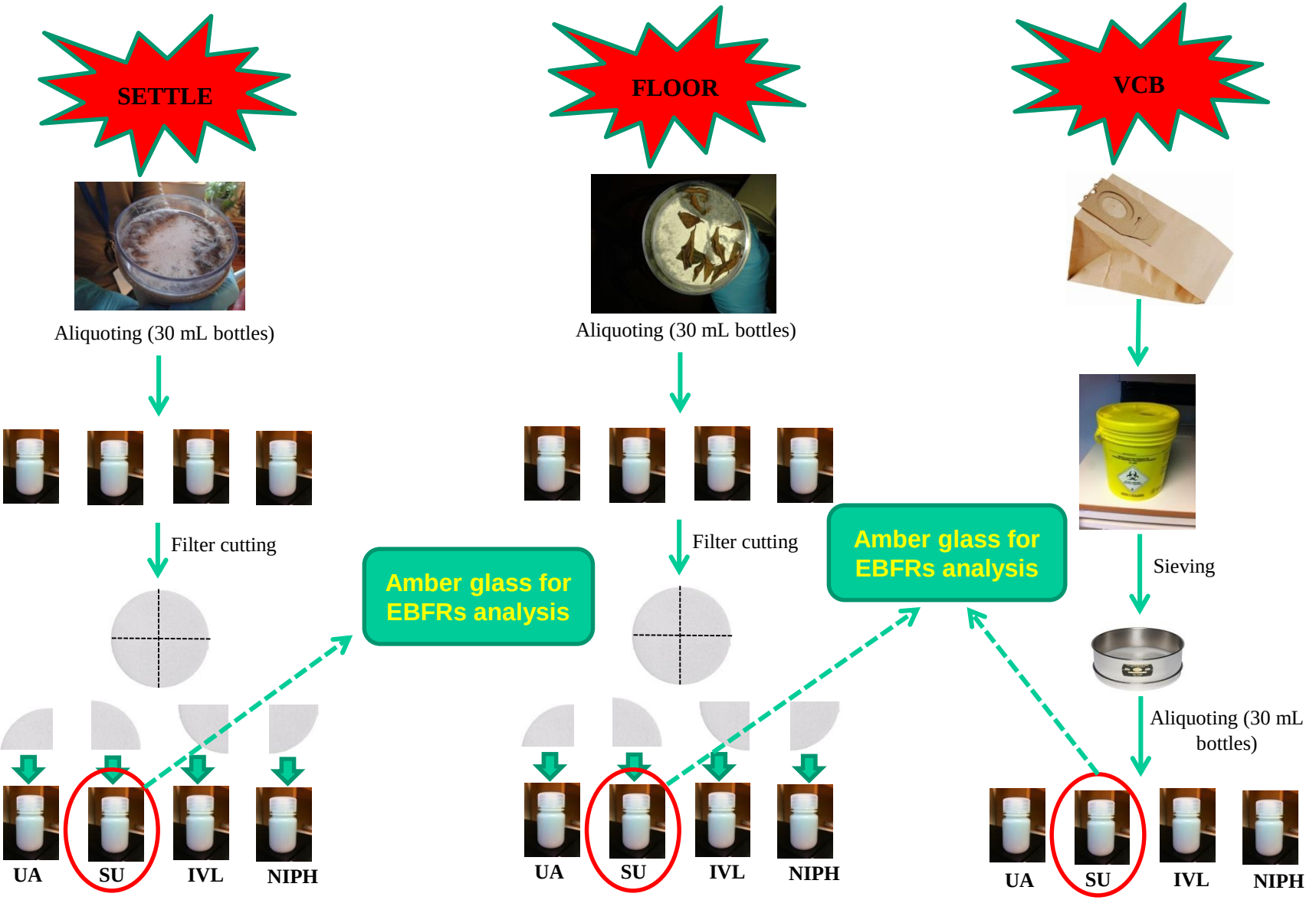
Wrap in Al foil

58 samples

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

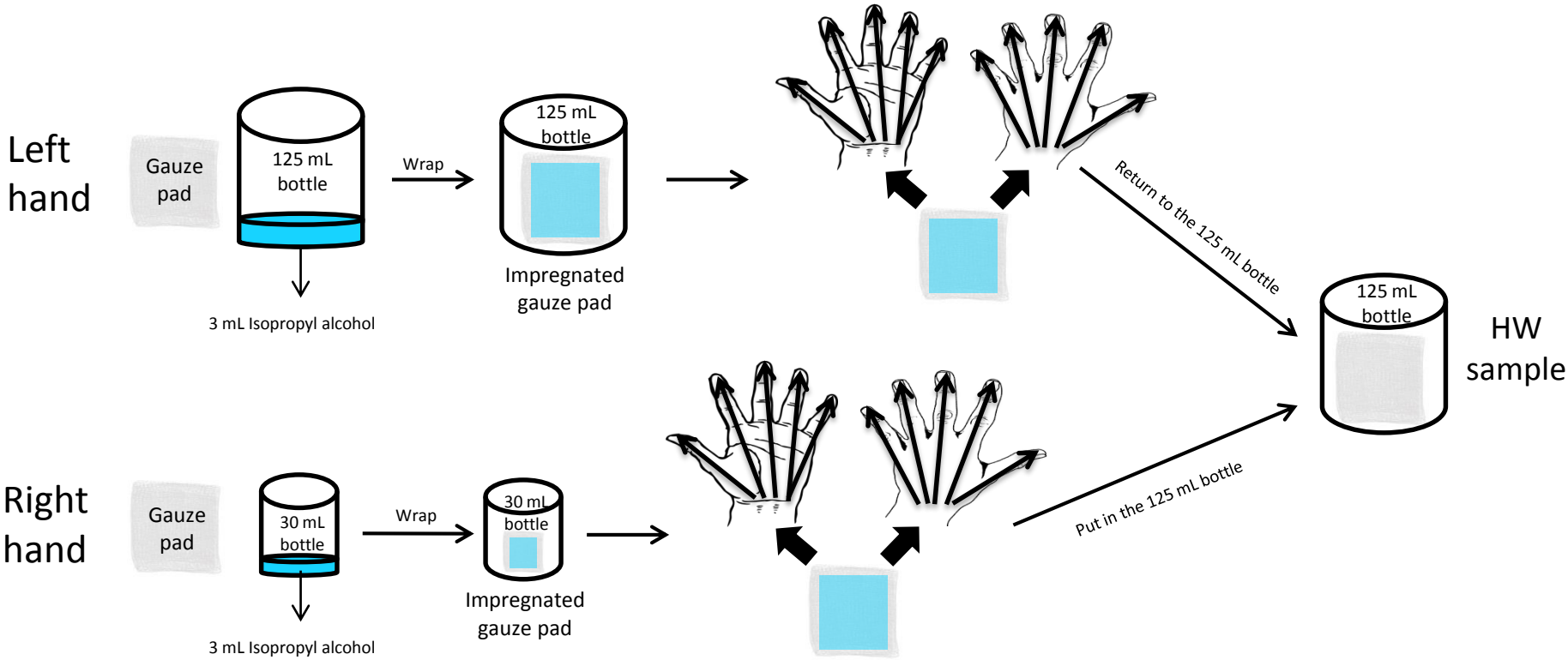
Indoor environment sampling strategies: Settle, Floor and VCB dust



Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

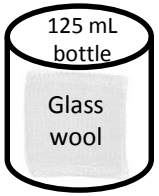
Indoor environment sampling strategies: Hand wipes



4 hand wipe samples

UA

NIPH



IVL

Glass wool preburned at 400C for phthalate analysis

SU

Amber glass for EBFRs analysis

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

OUTLINE

- Introduction
- A-TEAM indoor environment sampling strategies
    i. Home and personal air
    ii. Settle, floor and VCB dust
    iii. Hand wipes
- PFASs sample pre-treatment and analysis
    i. Indoor air
    ii. Indoor dust
- Results and discussion of PFASs in indoor environment
    i. Home air
    ii. Personal Air
    iii. Home vs personal air
    iv. Exposure assesment to PFOA
- A-TEAM Future Tasks
- Questions

Norwegian Institute of Public Health

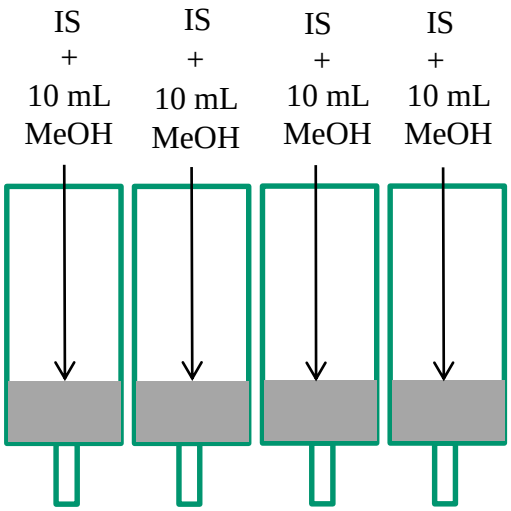
A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

PFASs sample pre-treatment and analysis: Indoor air

HOME AIR

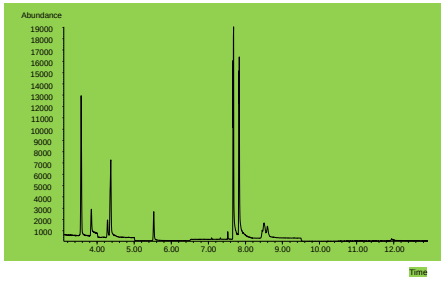
1 SKC Legacy pump 4 ENV+ cartrigdes
(0,2 g 6 mL) in parallel (1,25 L/min each)

24 h extraction



Evaporation of extract

Analysis GC-SIM-MS

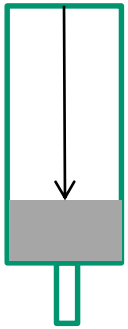


PERSONAL AIR

1 SKC personal pump 1 ENV+ cartrigdes
(1 g 25 mL) 1 mL/min

24 h extraction

IS + 10 mL MeOH x 4



Evaporation of extract

Analysis GC-SIM-MS

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

PFASs sample pre-treatment and analysis: Indoor dust

Total: **241** dust samples for PFASs analysis

Weighed and stored in 30 mL PP bottles

IS + MeOH 2 mL

Hand shaking 1 min

Rotary shaking 1 min

Filtration

Clean Up (Activated Carbon)

SPE-UPLC-TOF-MS (400 µL)

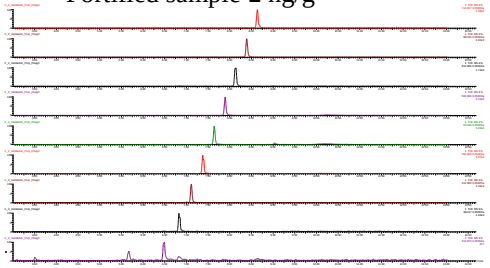
✓ No need to wheigh sample

✓ 2 min total extraction time

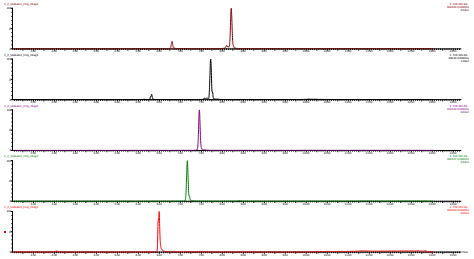
✓ 0,45 µm PP filters

✓ Clean-up is carried out in a on-line SPE-LC

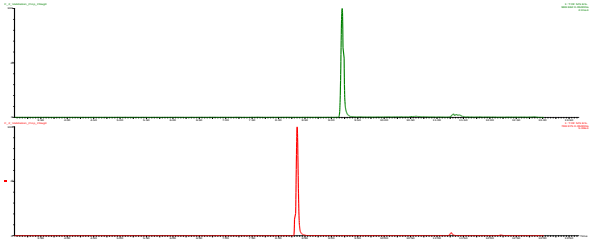
Perfluorocarboxylic acids (PFCAs)
Fortified sample 2 ng/g



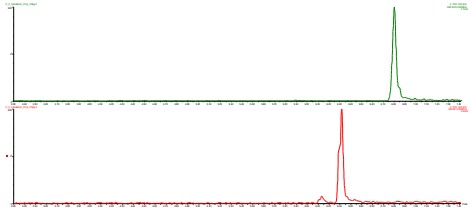
Perfluorosulfonates (PFSAs)
Fortified sample 2 ng/g



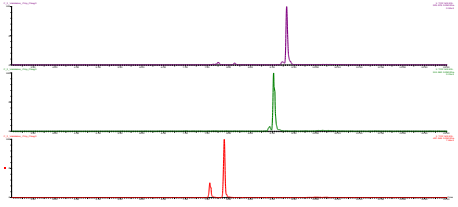
Polyfluoroalkyl phosphates (PAPs)
Fortified sample 2 ng/g



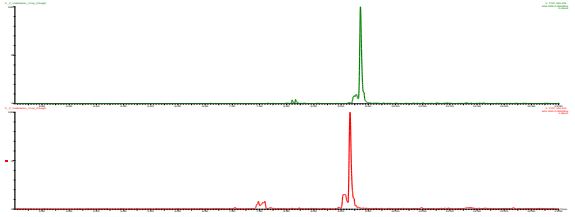
Polyfluoroalkyl phosphonates (PFPAs)
Fortified sample 2 ng/g



Perfluoroalkyl Sulfonamides (FOSAs)
Fortified sample 2 ng/g



Perfluoroalkyl Sulfonamidoethanols (FOSEs)
Fortified sample 2 ng/g



Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

OUTLINE

- Introduction
- A-TEAM indoor environment sampling strategies
    i. Home and personal air
    ii. Settle, floor and VCB dust
    iii. Hand wipes
- PFASs sample pre-treatment and analysis
    i. Indoor air
    ii. Indoor dust
- Results and discussion of PFASs in indoor environment
    i. Home air
    ii. Personal Air
    iii. Home vs personal air
    iv. Exposure assesment to PFOA
- A-TEAM Future Tasks
- Questions

Results and discussion of PFASs in indoor environment: Home air

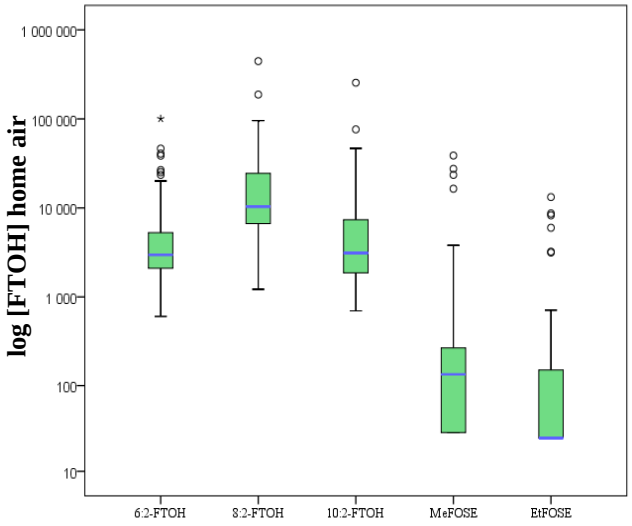
- **PFASs studied**: Volatile PFASs suspected to be precursors of the most persistent ones PFOS and PFOA.

Flurotelomer alcohols **(FTOHs)**

Polyfluorniated sulfonamides **(FOSAs)**

Polyfluorniated sulfonamidoethanols **(FOSEs)**

	Mean	Min	25th p	50th p	75th p	Max	N_{det}	$\%_{det}$	LODs
6:2-FTOH	**8551**	604	2098	2971	5284	100518	**61**	**100**	0,97
8:2-FTOH	**29419**	1217	6685	10363	24456	445602	**61**	**100**	1,42
10:2-FTOH	**12297**	697	1867	3115	7360	255078	**61**	**100**	0,03
EtFOSA	**797**	358	<LOD	<LOD	<LOD	1346	**4**	**7**	35
MeFOSA	**10147**	45	<LOD	<LOD	<LOD	78316	**8**	**13**	35
MeFOSE	**2966**	58	<LOD	134	267	38782	**42**	**70**	71
EtFOSE	**1552**	50	<LOD	<LOD	150	13242	**30**	**49**	50



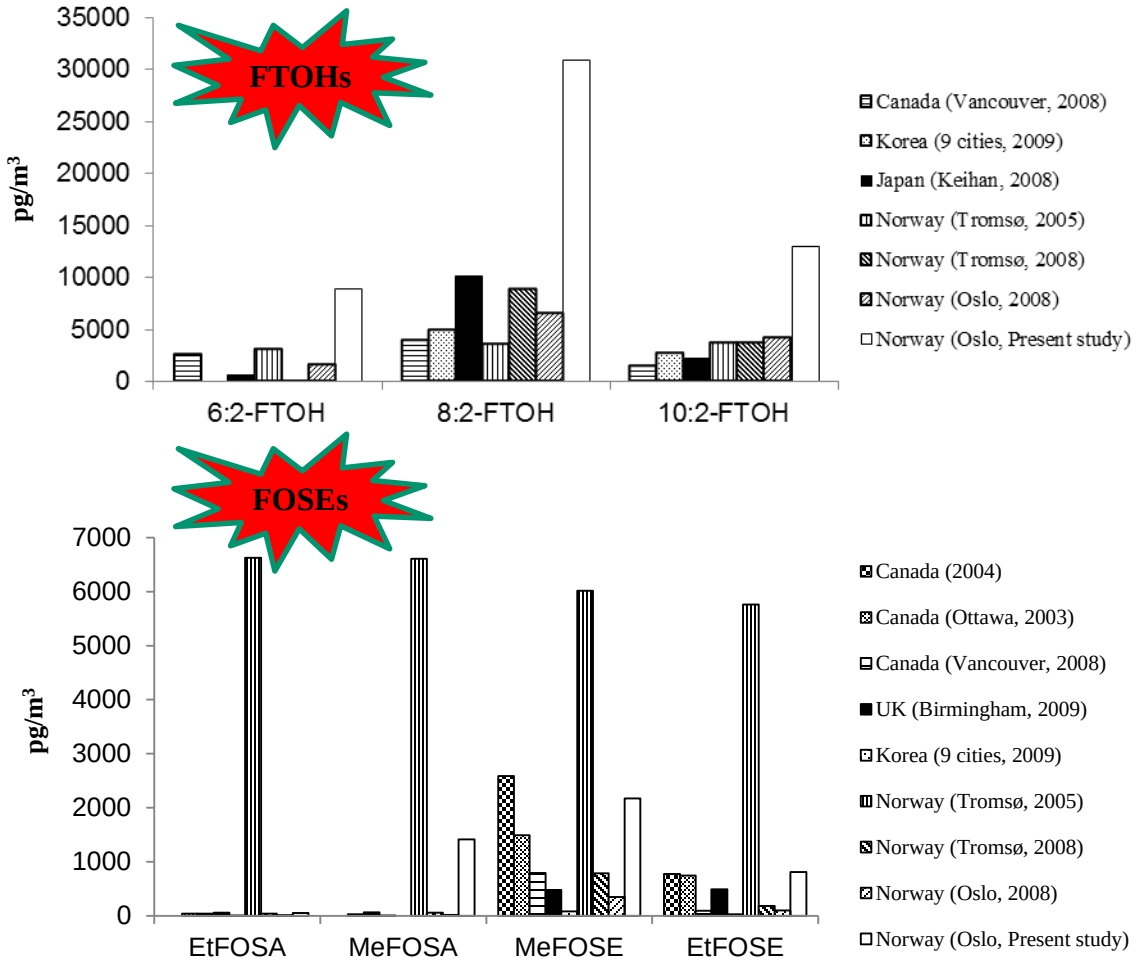
- FTOHs were detected in all samples (100%) in higher concentrations than FOSEs and FOSAs.
- 8:2-FTOH showed the highest concentrations among FTOHs, followed by 10:2-FTOH and 6:2-FTOH.
- MeFOSE, EtFOSE, MeFOSA and EtFOSA showed detection frequencies lower than FTOHs.
- Among FOSEs, MeFOSE showed higher concentrations than EtFOSE.
- Statistical results for FOSAs were not taken into account since their low detection frequency.

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

Results and discussion of PFASs in indoor environment: Home air

Comparisson of home indoor air results with past studies around the world



- FTOHs levels has increased previous works performed in Norway and other countries.
- Last data found about global production of FTOHs was estimated to be 5-6.5 x 10^6 kg/yr in 2000-2002 and 11-14 x 10^6 kg/yr in 2005 (*Dinglasan-Panlilio & Mabury 2006*).

Global production could be increased from 2005 until now

- FOSEs showed higher concentrations than past studies in Norway, Korea and UK, same levels than studies performed in Canada and less than one study performed in Norway in 2005.

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

Results and discussion of PFASs in indoor environment: Personal air

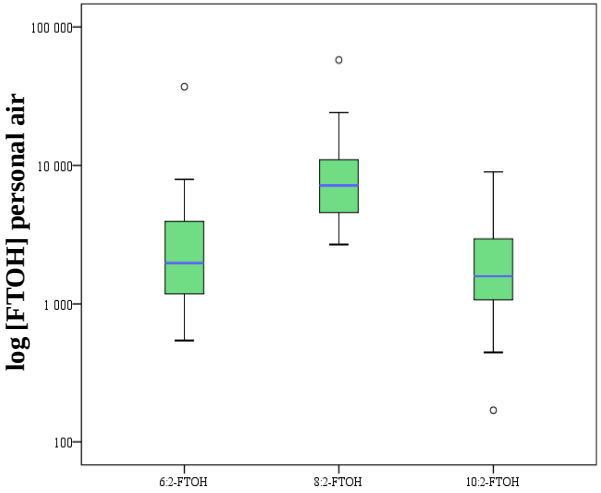
- **PFASs studied**: Volatile PFASs suspected to be precursors of the most persistent ones PFOS and PFOA.

Flurotelomer alcohols **(FTOHs)**

Polyfluorniated sulfonamides **(FOSAs)**

Polyfluorniated sulfonamidoethanols **(FOSEs)**

	Mean	Min	25th p1	50th p1	75th p1	Max	N_{det}	$\%_{det}$	LODs
6:2FTOH	**4872**	543	1182	1974	3953	37043	**15**	**100**	2,4
8:2FTOH	**11409**	2685	4576	7166	11142	57765	**15**	**100**	2,7
10:2FTOH	**2545**	170	1072	1585	2956	9000	**15**	**100**	1,4
EtFOSA	**65**	65	<LOD	<LOD	<LOD	65	**1**	**7**	70
MeFOSA	**225**	225	<LOD	<LOD	<LOD	225	**1**	**7**	70
MeFOSE	**765**	390	<LOD	<LOD	<LOD	1105	**3**	**20**	350
EtFOSE	**<LOD**	<LOD	<LOD	<LOD	<LOD	<LOD	**<LOD**	**<LOD**	350



- FTOHs were detected in all samples (100%) ➡ Same as in home indoor air samples
- 8:2-FTOH showed the highest concentrations among FTOHs followed by 6:2-FTOH and 8:2-FTOH.

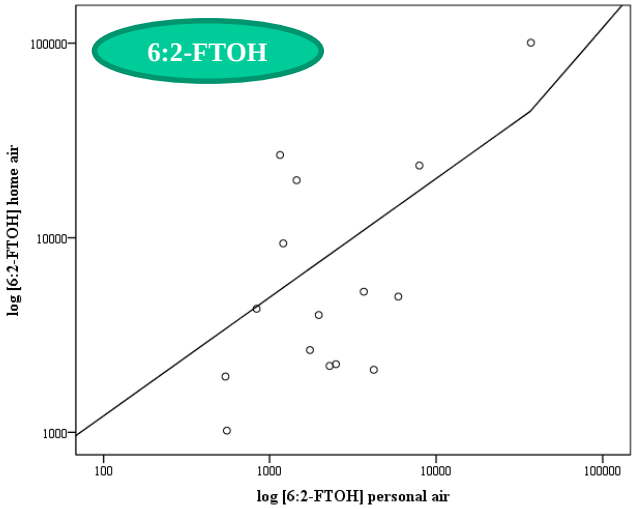
8:2, 6:2 and 10:2-FTOH concentrations in personal air 3, 2 and 6 times lower than home air

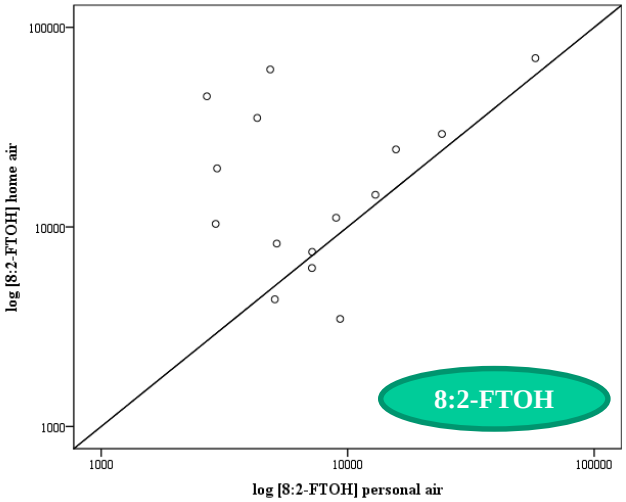
Different pattern: 6:2 FTOH>10:2-FTOH in personal air

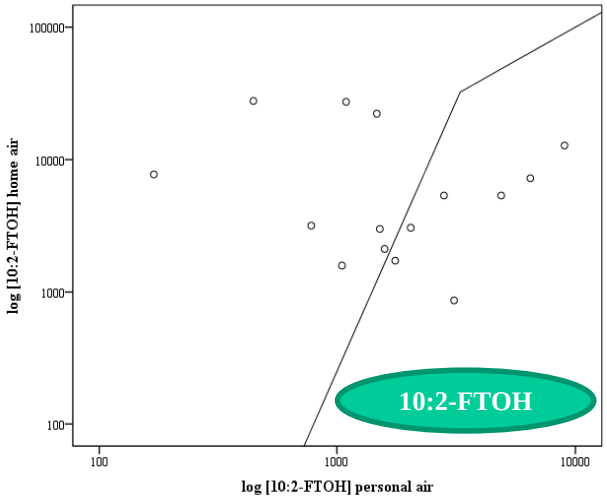
- MeFOSE was detected in 3 out of 15 samples while EtFOSE was not detected over the LOD.
- Statistical results for FOSAs were not considered since their low detection frequency.

Results and discussion of PFASs in indoor environment: Home vs personal air

Scatter plots were used in order to find out the trend of FTOHs both in home and personal air







- 8:2-FTOH showed certain linearity → Most abundant compound both in home and personal air
- 6:2 and 10:2-FTOH showed more dispersion → Different patter found
  - 6:2-FTOH<10:2-FTOH in home air
  - 6:2-FTOH>10:2-FTOH in personal air

No significant correlation was found bteween FTOHs in personal and home air

Norwegian Institute of Public Health

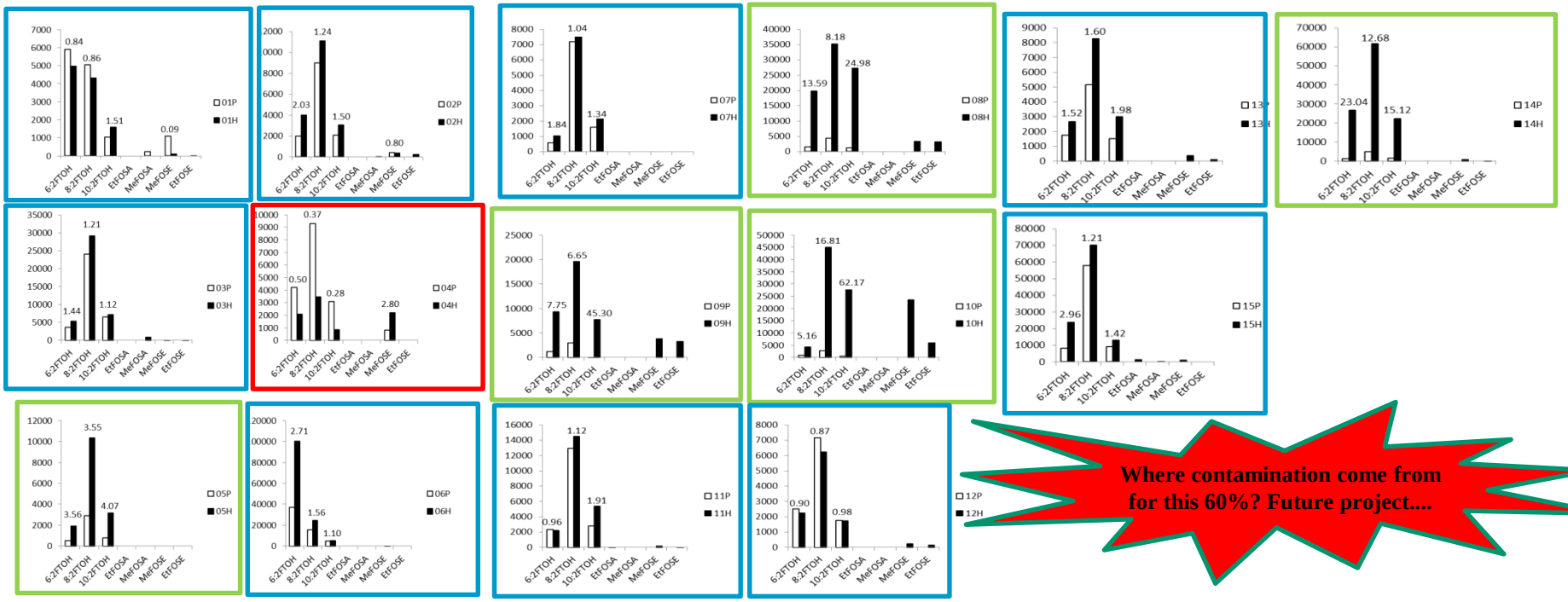
A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

Results and discussion of PFASs in indoor environment: Home vs personal air

Home/personal air ratios (H/P) were used to compare the exposure of the participants to PFASs in home and personal air

Home air 

Personal air 



Where contamination come from for this 60%? Future project....

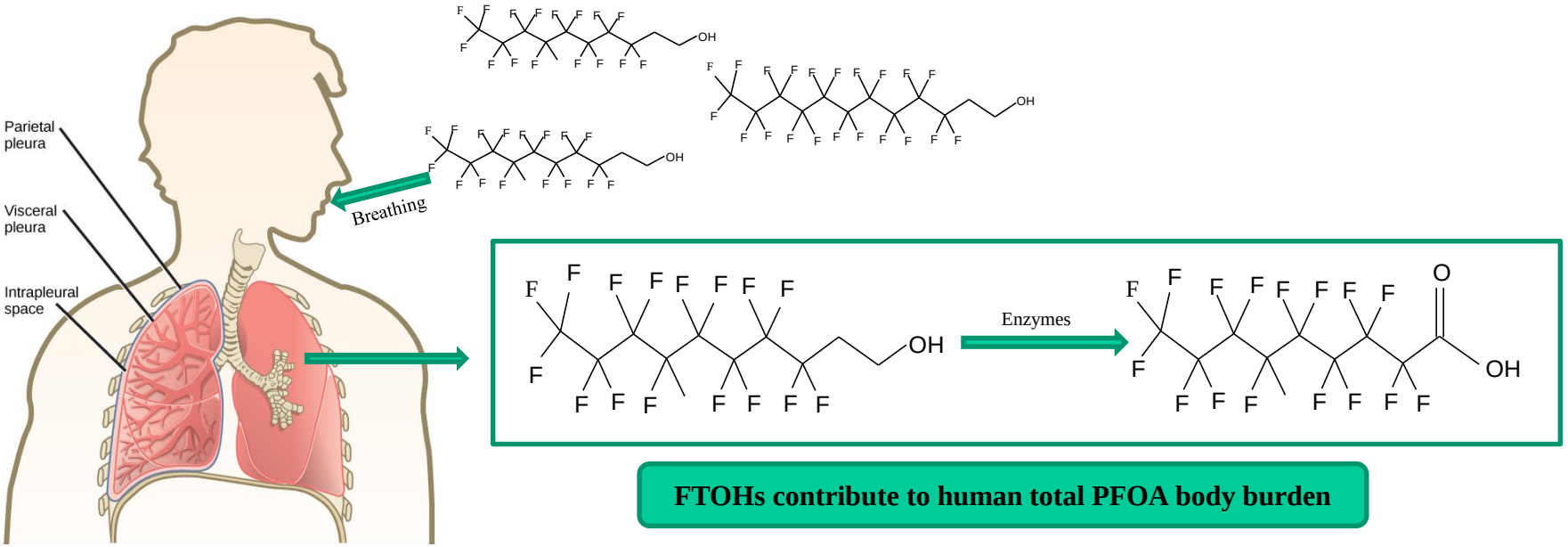
- 5 out of 15 showed clearly higher levels for all FTOHs in home air, showing H/P ratios in range 3.55 (8:2-FTOH)-62.17 (10:2-FTOH)
- 9 out of 15 showed similar levels of all FTOHs both in personal and home air with H/P ratios in range 0.84 (6:2-FTOH)-2.03 (6:2-FTOH)
- 1 out of 15 showed clearly higher concentrations of FTOHs in personal air with H/P ratios 0.50, 0.37 and 0.28 for 6:2, 8:2 and 10:2-FTOH, respectively

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

Results and discussion of PFASs in indoor environment: Exposure assesment to PFOA

Several works reported evidence of biotransformation of FTOHs to PFOA → **Listed as POP in the Stockholm convention**



- Doing several assumptions:
  - ✓ FTOHs are easily absorbed through lungs, as was suggested for PFOA (*Kennedy et al. 2004*)
  - ✓ Average male and female inhalation rate is 15 L/min (assuming 66% light activity and 33% resting) (*Martin et al. 2005*)
  - ✓ Biotransformation rate reported of 8:2-FTOH to PFOA is 0.012 in human hepatocytes (*Nabb et al. 2007*)

↓

Possible to estimate total indirect intake of PFOA through air

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

Results and discussion of PFASs in indoor environment: Exposure assesment to PFOA

Results of 8:2 and 10:2-FTOH in personal air were used in order to estimate indirect PFOA intake through indoor air

Participant	FTOH concentrations in personal air (ng/m^3)			FTOHs intake estimation (ng/day)			PFOA intake estimation (ng/day)	
	6:2-FTOH	8:2-FTOH	10:2-FTOH	6:2-FTOH	8:2-FTOH	10:2-FTOH	8:2-FTOH biotransformation	10:2-FTOH biotransformation
1	5.9	**5.1**	1.1	128	109	23	**1.313**	0.272
2	2.0	**9.0**	2.0	43	194	44	**2.327**	0.528
3	3.7	**24.1**	6.5	80	521	140	**6.252**	1.677
4	4.2	**9.3**	3.1	91	201	67	**2.416**	0.803
5	0.5	**2.9**	0.8	12	63	17	**0.756**	0.202
6	37.0	**15.7**	4.9	800	339	106	**4.070**	1.267
7	0.6	**7.2**	1.6	12	155	34	**1.861**	0.411
8	1.5	**4.3**	1.1	31	93	24	**1.114**	0.283
9	1.2	**3.0**	0.2	26	64	4	**0.766**	0.044
10	0.8	**2.7**	0.4	18	58	10	**0.696**	0.116
11	2.3	**13.0**	2.8	50	280	61	**3.360**	0.729
12	2.5	**7.2**	1.8	54	155	38	**1.857**	0.455
13	1.7	**5.2**	1.5	38	111	33	**1.337**	0.393
14	1.2	**4.9**	1.5	25	105	32	**1.258**	0.381
15	7.9	**57.8**	9.0	171	1248	194	**14.973**	2.333

- FTOHs estimated intakes during one day were in range **4 ng (10:2-FTOH)-1248 ng (8:2-FTOH)**

- Estimated FTOHs intakes 300 and 600 times more in this study than intakes predicted with outdoor FTOHs concentrations in air (*Martin et al, 2005*): 0.2 and 2 ng FTOH/day

- PFOA indirect intakes were in range **0.7-15 and 0.04-2 ng PFOA/day from 8:2-FTOH and 10:2-FTOH** biotransformation, respectively

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

OUTLINE

- Introduction
- A-TEAM indoor environment sampling strategies
    i. Home and personal air
    ii. Settle, floor and VCB dust
    iii. Hand wipes
- PFASs sample pre-treatment and analysis
    i. Indoor air
    ii. Indoor dust
- Results and discussion of PFASs in indoor environment
    i. Home air
    ii. Personal Air
    iii. Home vs personal air
    iv. Exposure assesment to PFOA
- A-TEAM Future Tasks
- Questions

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

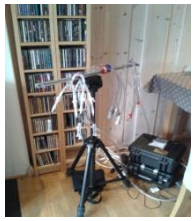
A-TEAM Future Tasks

Personal air

Settle dust

Hand wipes

Home air



Floor dust

VC Bag dust

Food

VS

Blood

Which pathways are the best indicator of PFASs human body burden?

Norwegian Institute of Public Health

A·TEAM
ADVANCED TOOLS FOR EXPOSURE ASSESSMENT AND BIOMONITORING

THANKS FOR YOUR ATTENTION!

A-TEAM
SAMPLING TEAM

A-TEAM
PARTICIPANTS

A-TEAM OSLO