



Vlaanderen
is omgeving

**FLEHS: The Flemish
Environment and Health
Survey:
from knowledge to policy:
interpretation, participation
and action**

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**DEPARTEMENT
OMGEVING**





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3 parts: What is FLEHS? PFAS@home HBM-3M

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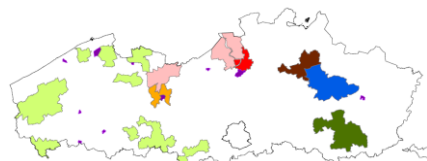
FLEHS: a 20-year mirror of the Flemish population

1st cycle (2002-2006)
8 areas with a different type of environmental pressure

2nd cycle (2007-2011) Flemish reference values + specific areas of interest

3th cycle (2012-2015)

4th cycle (2016-2020)
Flemish reference values + subgroups with specific characteristics



Menen



Genk



Genth harbour



Green spaces



Indoor



Eco nutrition



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The Flemish Environment and Health Survey (FLEHS)

- ▶ **'human analysis'** -> a.o. blood, hair and urine: research of human exposure to chemicals and the relationship with (early) health effects
- ▶ **direct and integrated** (also mixtures) blueprint of pollutants present in humans
- ▶ **early warnings:** before occurrence of disease, also positive health effects
- ▶ **Personal involvement of participants** in scientific research and environmental policy
-> 'pollution gets personal'

Based on:

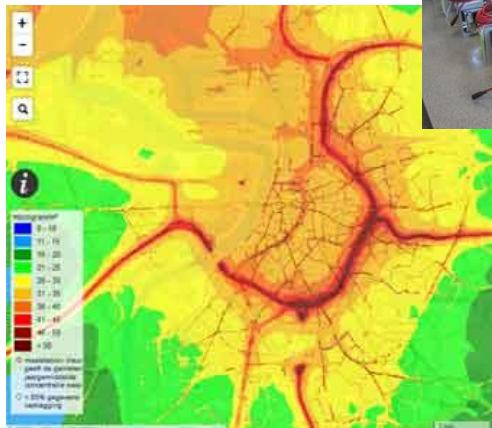
- **Participation and involvement:** in study design, communication of results and policy translation
- **Transparency:** every participant receives his personal results before public communication
- **Multidisciplinarity and trust:** close cooperation between science and policy during the whole process starting with the research question

Exposome approach

Perception, well-being and social-economic position

- Questionnaires about perception of the living environment, time spent in a green environment, ...
- Type of education, nationality, income, home language,....

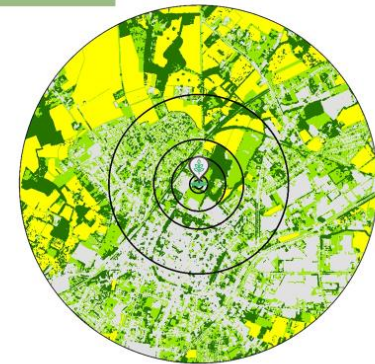
Spatial ecosystem and (determinants of) exposure



Groenkaart Vlaanderen (resolutie 1 m²)

Agentschap voor Natuur en Bos
Agentschap voor Geografische Informatie

- Hoog groen (> 3m)
- Laag groen (< 3m)
- Landbouw



0 0.5 1 2 3 4 Kilometers

Percentage groene ruimte rondom de woning

- 50 meter
- 100 meter
- 300 meter
- 500 meter
- 1000 meter
- 2000 meter

Life style



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	FLEHS I (2002-2006)	FLEHS II (2007-2011)	FLEHS III (2012-2015)	FLEHS I (2016-2020)
<u>Metals/trace elements</u>				
<u>Dioxines/furans</u>				
<u>Organochloride pesticides</u>				
<u>PCBs</u>				
<u>PAHs</u>				
<u>Benzene</u>				
<u>Phtalates</u>				
<u>Bisphenols</u>				
<u>Perfluorinated compounds</u>				
<u>Pesticides</u>				
<u>Brominated flame retardants</u>				
<u>Organophosphate flame retardants</u>				
<u>Nicotine</u>				
<u>Personal care products</u>				

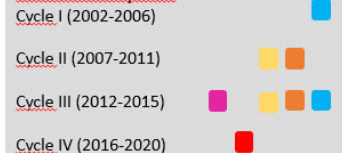
Internal exposure
(~8000 participants)

Health effects

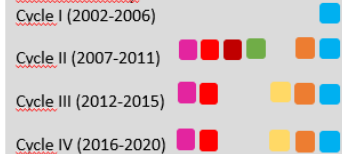
Neurological development



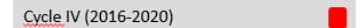
Immunoresponse



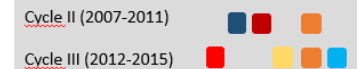
Genotoxicity



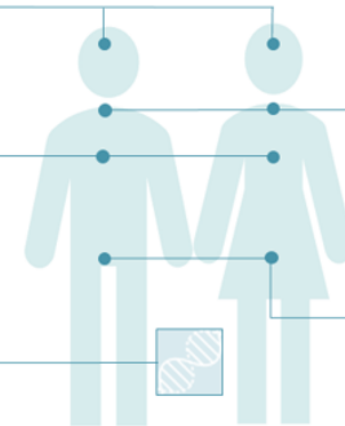
Biological stress (cortisol in hair)



Hormone disruption (thyroid hormones)



Hormone disruption



Metals and trace elements

POP's

Softeners (phtalates)

Perfluorinated compounds (PFAS)

Pesticides

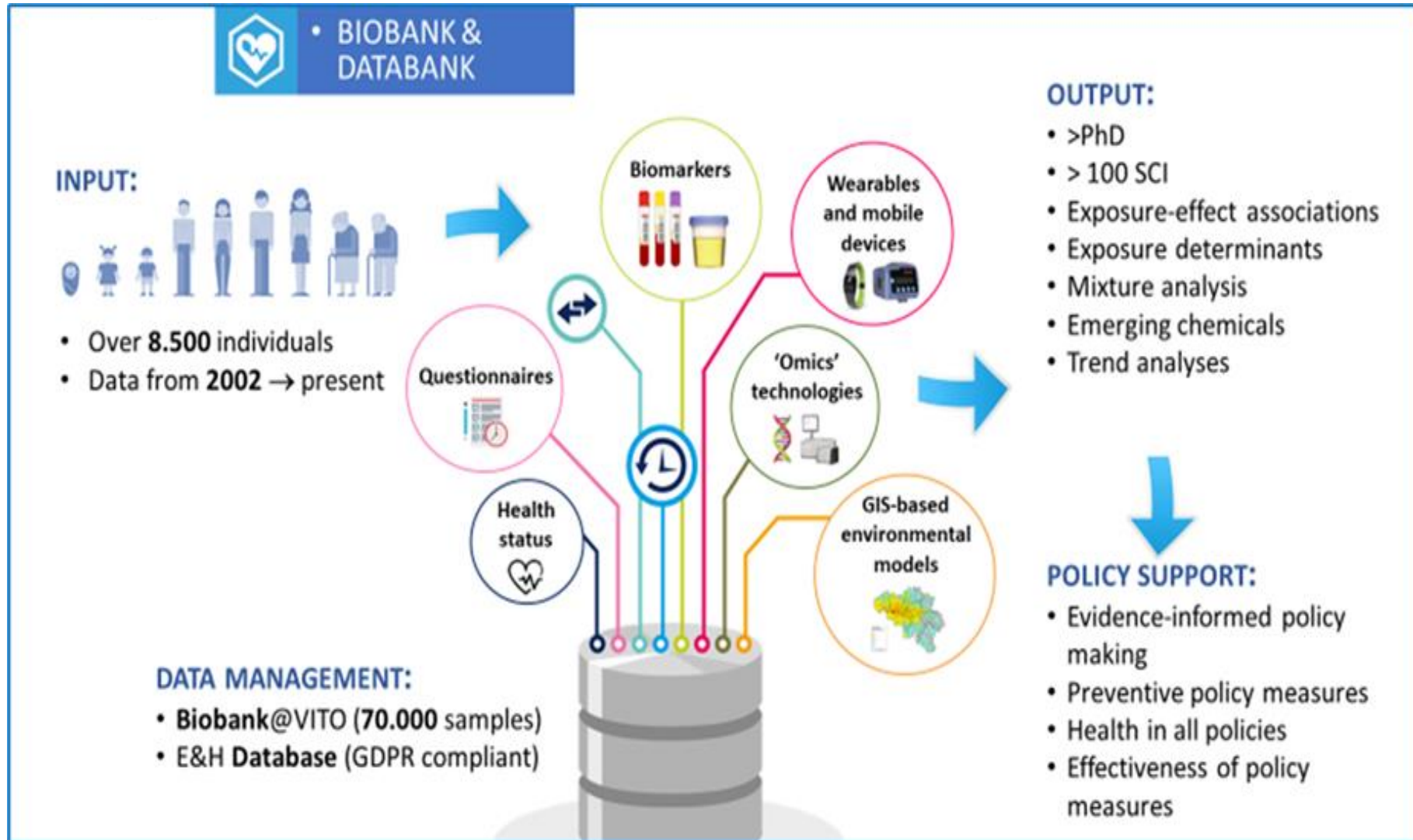
Brominated flame retardants

Softeners (bisphenols)

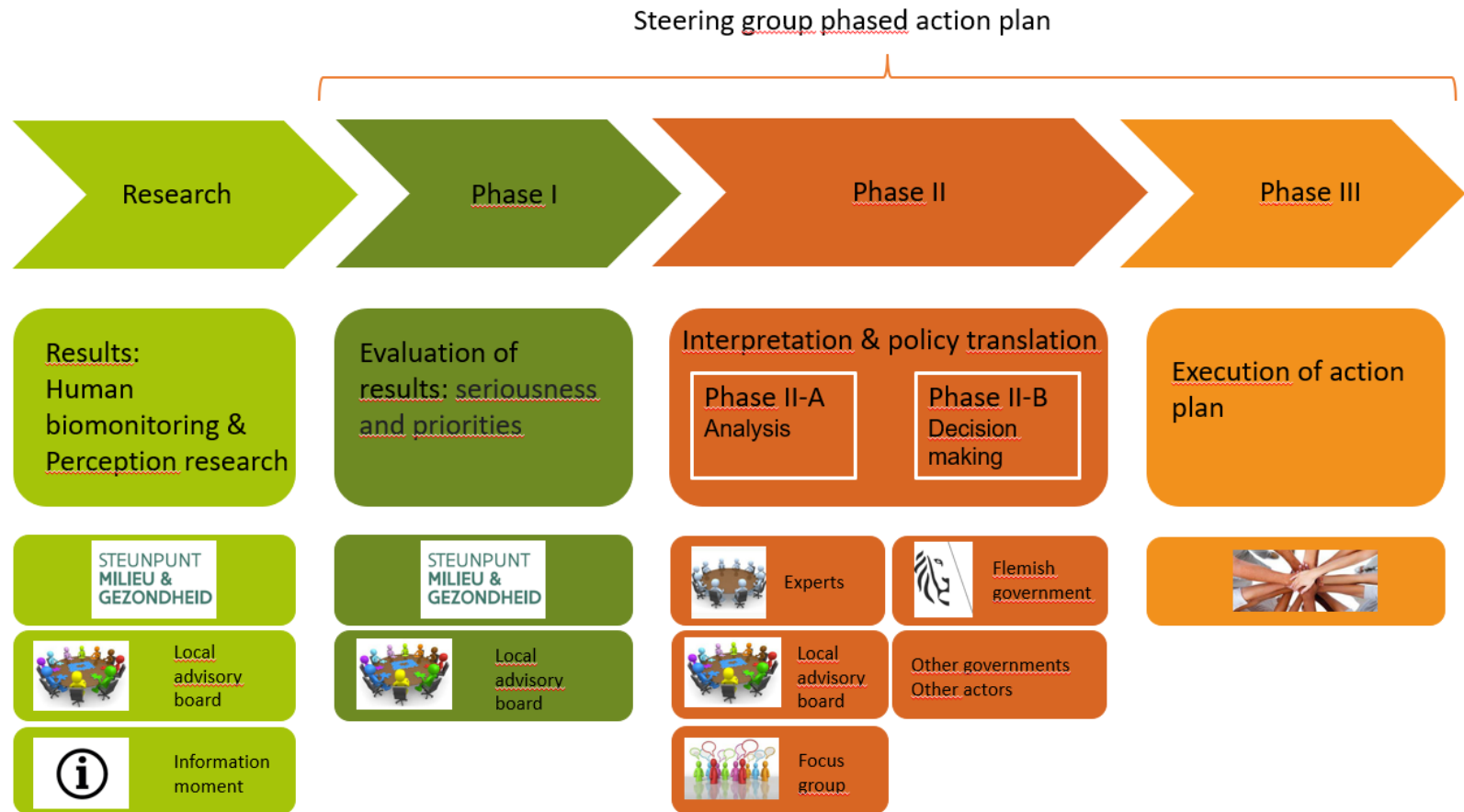
Polyaromatic hydrocarbons (PAHs)

Benzene

FLEHS: a 20-year mirror of the Flemish population



Phased action plan = step by step consultation on policy translation of HBM results



Resulting action plans

Actieplan schuift bronnenonderzoek en opvolging effecten mens en milieu naar voren

“Open communicatie centraal”

■ **MENEN** – Een milieubeurs voor leerkrachten, een educatief pakket voor kleuters maar vooral een werkgroep waar burgers, overheid en industrie vertegenwoordigd zijn, worden de belangrijkste pijlers van het actieplan humane biomonitoring.



Bij het opmaken van het actieplan ging de overheid niet over een nacht ijs. Er werden verschillende instanties en instellingen aangesproken om mee te werken. (foto PWM)

probleem in Menen en we moeten dan ook alle drie de betrokken partijen op een lijn krijgen. We beseffen dat het niet makkelijk, daarom kiezen we voor de externe consultant”, geeft milieusambenaar Hannelore Zoetardt mee.

Milieubeurs

Menen wachtte echter niet om op het actieplan om al een eerste initiatief te nemen. Zo is er op 8 oktober een milieubeurs voor leerkrachten. “Er gebeuren nog te veel zaken die we niet kunnen goedkeuren, zoals bijvoorbeeld de aanteg van moestuintjes. We weten dat het vaak goed bedoeld is. Daarom plannen we begin oktober drie informatieve beurs voor leerkrachten. Daarbij hoort ook het educatieve pakket voor kleuters dat we aan de scholen zullen aanbieden”, aldus Hannekore. Ze verwijst nog even naar het cijferonderzoek waarvan de resultaten in 2014 bekend gemaakt zullen worden. “Uit het onderzoek bleek ook dat de jongeren minder pb’s en dioxines in hun bloed hadden dan ekers in Vlaanderen. Dat werd verklaard doordat er in Menen amper groenten uit eigen tuin of cities van schaarlijkgeen gegeten werden. Door de eieren te onderzoeken, wordt nu nagegaan in hoeverre het opnieuw veilig is om die eitjes te eten.” (Lien)

van Leeftijd en Gezondheid goedgekeurd werden”, klinkt het.

Externe consultant

Karen Van Campenhout mocht voor het Vlaams Agentschap Zorg en Gezondheid het actieplan voorstellen. “Het plan heeft drie prioriteiten. Enerzijds is er de bronaanpak en in tweede instantie gaan we

de effecten op mens en milieu verder opvolgen. Ik denk bijvoorbeeld aan de verhoogde aanwezigheid van thalium waarover we eigenlijk nog niet zo veel weten. De derde prioriteit is dan communicatie en informatie omdat we vaststellen dat er nog altijd te weinig gecommuniceerd wordt met alle betrokken partijen.”

E-missie plan Genk-Zuid

versie december 2013



Actieplan flin stof en NO voor agglomeratie Gent en Gentse kanaalzone (2016 – 2020)

WWW.ACTIEPLANGENTBE



Action plan on chlorinated compounds and action plan astma presented by ministers



Action plan

Strengthen existing policy

Extra source measures

Extra follow-up in humans and environment

Extra communication and information



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Internal and external evaluation: some focus points

- ▶ Involvement of different scientific disciplines, societal actors and policy is very fruitfull, but also complex
→ we often speak 'another language'
- ▶ “Learning by doing” - > every FLEHS campaign is different-> flexible procedure necessary
- ▶ Stakeholder participation = essential and needs to be well defined
- ▶ Open communication of HBM results and all steps in policy translation are key elements in awareness raising
- ▶ Focus on concrete problem solving (action plans)
- ▶ Independence = essential -> external process management



Vlaanderen
is omgeving

PFAS@home

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WE MAKE
TOMORROW
BEAUTIFUL
OVAM



Why?



- ▶ Measurement of PFAS in FLEHS since 2007
- ▶ Significant part of participants above health based guidance values
→ Sources and uptake routes not clear or unknown
- ▶ Policy translation of FLEHS results to action

Why?

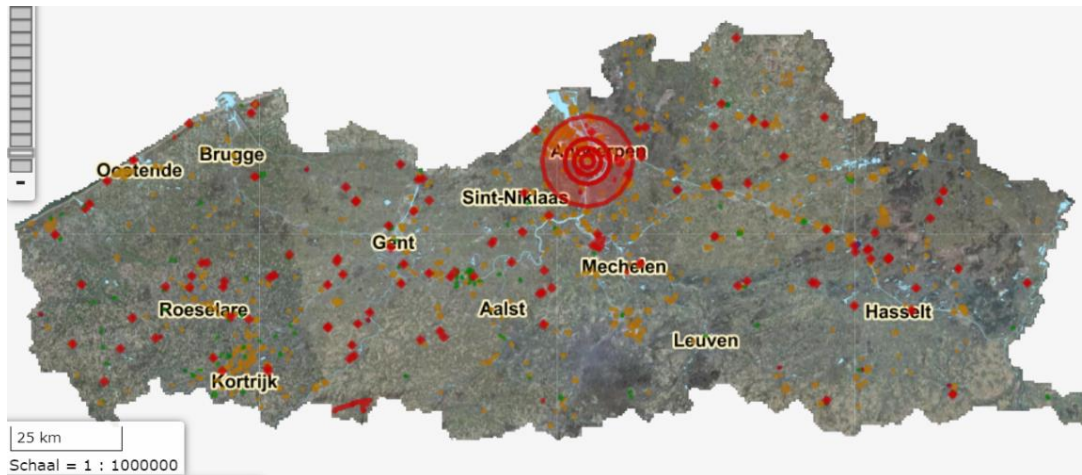
Exploratory study of PFAS in our environment (**proof of concept**), development of methodology for following questions:

1. What are the **levels of PFAS** in the different environmental compartments in and around dwellings in Flanders, and by extension crops and home-grown animal products?
2. To what extent can these environmental compartments **contribute to human exposure**?
3. Can **influencing factors** be associated with the observed variation in PFAS concentrations be identified?
4. What **policy recommendations** can be formulated and how can this POC be implemented in a wider scope?

Participant selection



- 19 participants
 - 6 girls, 13 boys between 17 and 19 (in 2021)
 - Small study population
 - Vegetable garden and/or chicken coop



- ▶ **PFAS no-regret zones**
 - No participants in this zones
 - Distance to nearest zone
 - × Median: 3140 m
 - × Range: 129m – 5472 m

Environmental measurements

N=19



Eggs chicken → 1 mixing sample/participant

N=15



Vegetables own garden → 4 kinds of vegetable/participant

N=19

N=15



Soil



Chicken coop → 1 mixing sample/participant

Vegetable garden → 1 mixing sample/participant

N=19



House dust → 1 mixing sample/participant

N=19



Serum → 1 mixing sample/participant

N=15/19/19



Water → 1 vegetable garden, 1 chicken, 1 tap water/
participant

N=6



Compost → 1 mixing sample/participant



Questionnaires

- ▶ **Short questionnaire with selection questions together with informed consent**
- ▶ **Questionnaire for interpretation of results**
 - Chicken and chicken coop
 - Vegetable garden
 - The house and the indoor environment
 - Use of pesticides
 - Consumption of home grown food



Which PFAS are measured?

► Measuring the same PFAS in different matrices

PFAS	Afkorting	CAS nr
Perfluor carboxyl zuren (PFCA's)		
perfluoro-n-butaanzuur	PFBA	375-22-4
perfluor-n-pentaanzuur	PFPA	2706-90-3
perfluor-n-hexaanzuur	PFHxA	307-24-4
perfluor-n-heptaanzuur	PFHpA	375-85-9
perfluor-n-octaanzuur	PFOA	335-67-1
perfluor-n-nonaanzuur	PFNA	375-95-1
perfluor-n-decaanzuur	PFDA	335-76-2
perfluor-n-undecaanzuur	PFUdA	2058-94-8
perfluor-n-dodecaanzuur	PFDoA	307-55-1
perfluor-n-tetradecanoic acid	PFTeDA	376-06-7
Perfluor sulfonaat zuren (PFSA's)		
perfluor-n-butaansulfonzuur	PFBS	375-73-5
Perfluor-n-pentaansulfonzuur	PFPeS	2706-91-4
perfluor-n-hexaansulfonzuur	PFHxS	355-46-4
perfluor-n-heptaansulfonzuur	PFHpS	375-92-8
perfluor-n-octaansulfonzuur	PFOS	1763-23-1
Precursoren en vervangproducten		
4:2 fluortelomeersulfonzuur	4:2 FTS	757124-72-4
6:2 fluortelomeersulfonzuur	6:2 FTS	27619-97-2
8:2 fluortelomeersulfonzuur	8:2 FTS	39108-34-4
hexafluorpropyleenoxidedimeerzuur	HFPO-DA (GenX)	13252-13-6
4,8-dioxa-3H-perfluornonaanzuur	ADONA	919005-14-4

Quantitative measurement in all matrices (soil, eggs, vegetable, house dust and serum) 20 PFAS

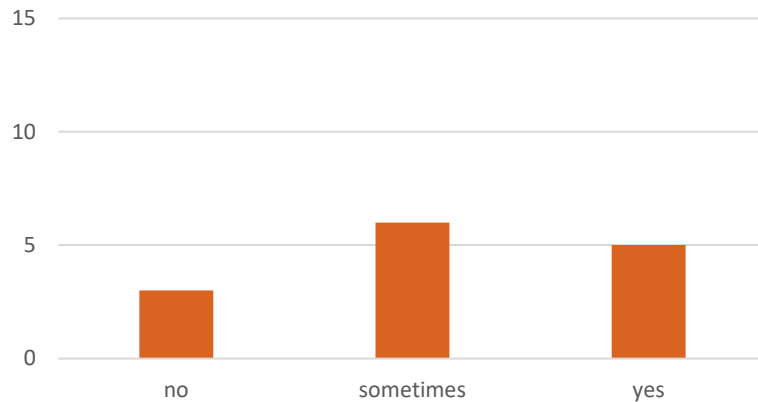
PFAS	Afkorting	CAS nr
perfluor-n-tridecaanzuur	<u>PFTrDA</u>	72629-94--8
perfluor-1-decaansulfonzuur	PFDS	335-77-3

Indicative measurement in soil, vegetables, house dust and serum. Quantitative measurement in eggs

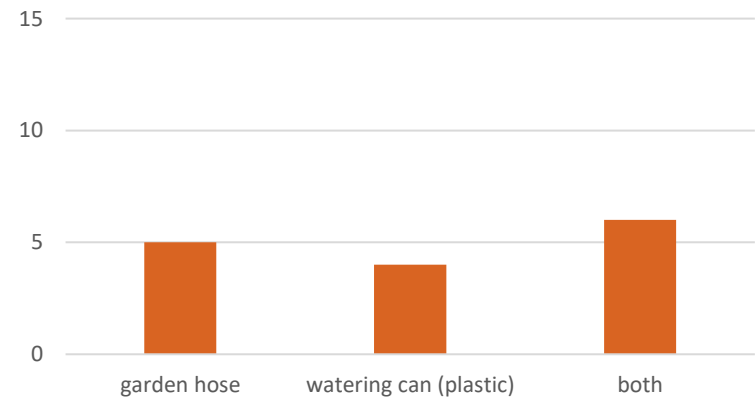


Results – soil (vegetable garden)

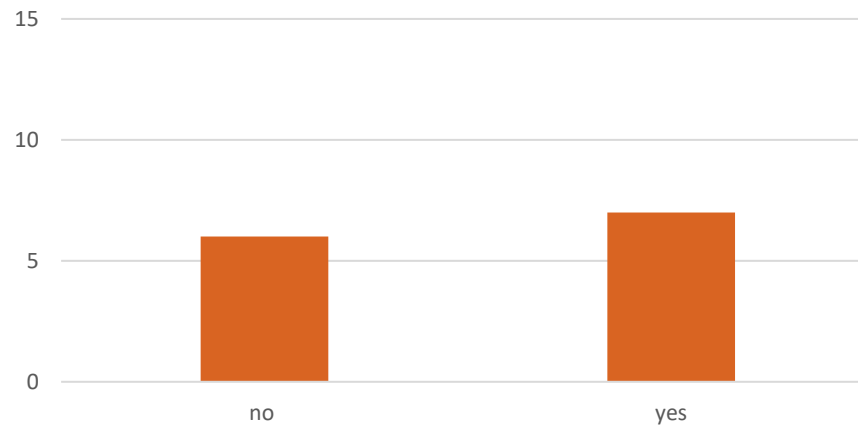
Use of compost (number of participants)



Which material is used to water the garden? (number of participants)



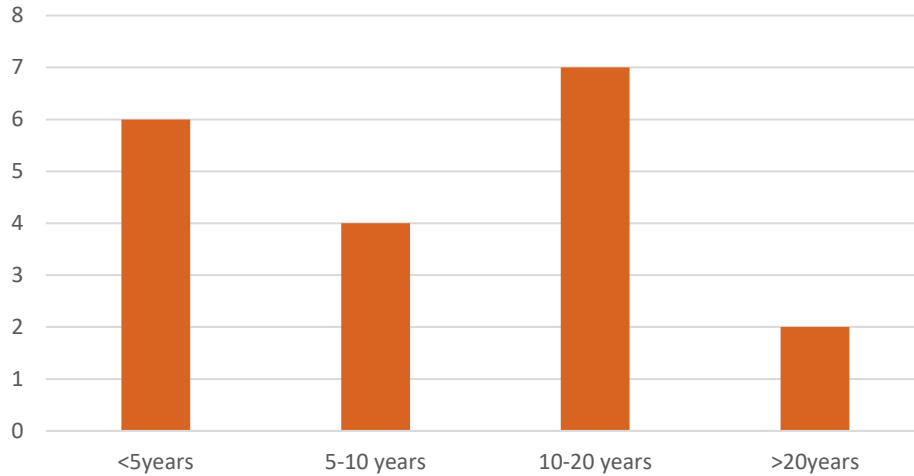
Use of pesticides (number of participants)



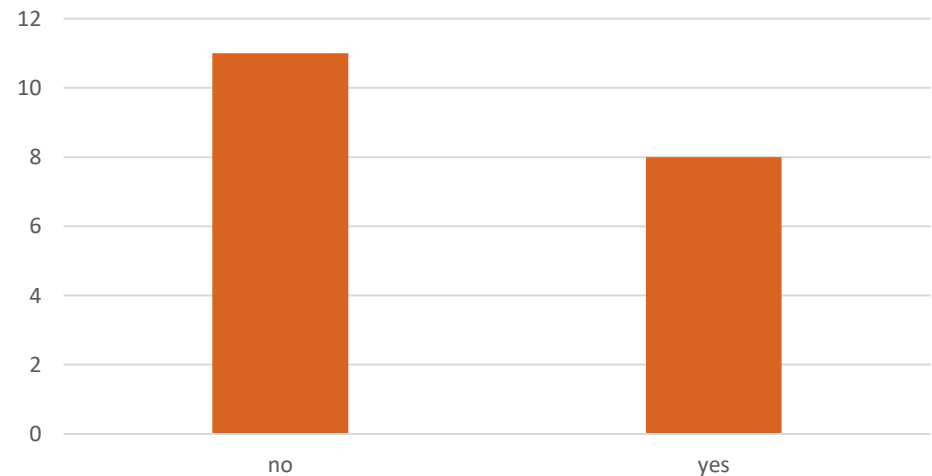


Results – soil (chicken coop)

Chicken coop age (number of participants)



Use of insecticides (number of participants)



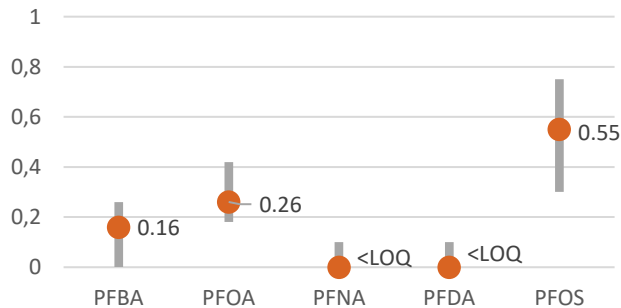


Results – soil (vegetable garden and chicken coop)

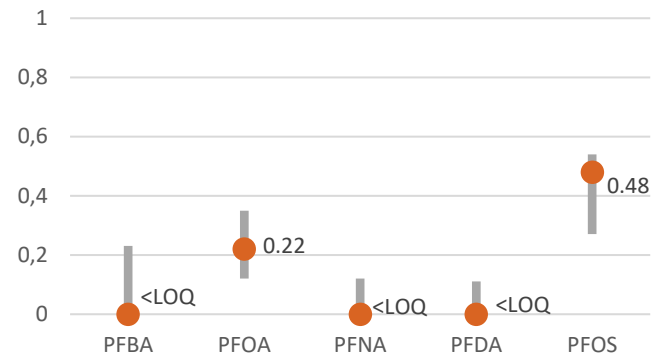
- PFOS and PFOA most dominant PFAS
- Levels are similar to background levels



Soil of vegetable garden
($\mu\text{g}/\text{kg ds}$)



Soil of chicken coop ($\mu\text{g}/\text{kg ds}$)



Median
P25-P75

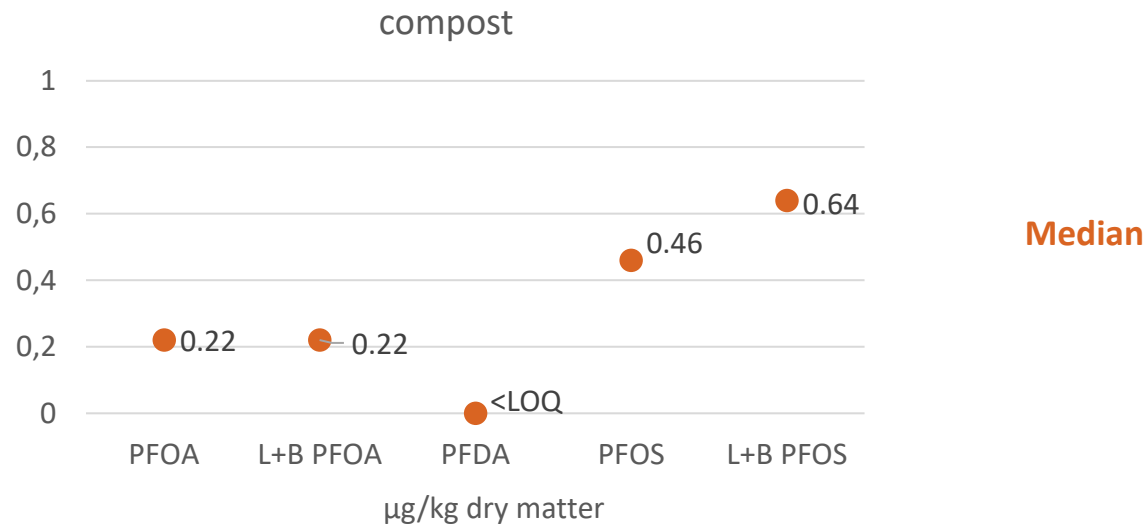
	PFOA	PFOS	PFOA	PFOS
Guidance value residential area with garden	> 4,3 $\mu\text{g}/\text{kg ds}$ 0 / 15	> 3,8 $\mu\text{g}/\text{kg ds}$ 1 / 15	> 4,3 $\mu\text{g}/\text{kg ds}$ 0 / 15	> 3,8 $\mu\text{g}/\text{kg ds}$ 0 / 15
Background value	> 1 $\mu\text{g}/\text{kg ds}$ 0 / 15	> 1,5 $\mu\text{g}/\text{kg ds}$ 1 / 15	> 1 $\mu\text{g}/\text{kg ds}$ 0 / 15	> 1,5 $\mu\text{g}/\text{kg ds}$ 0 / 15





Results – compost

- Only 6 samples!
- Dominant PFAS: PFOS, L+B PFOS, PFOA and L+B PFOA

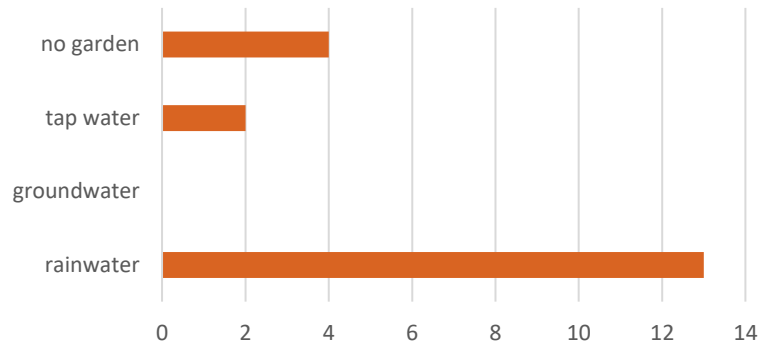




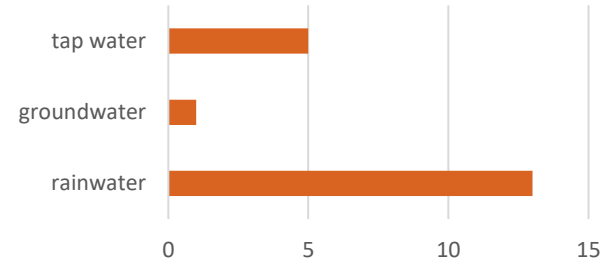
Results – water



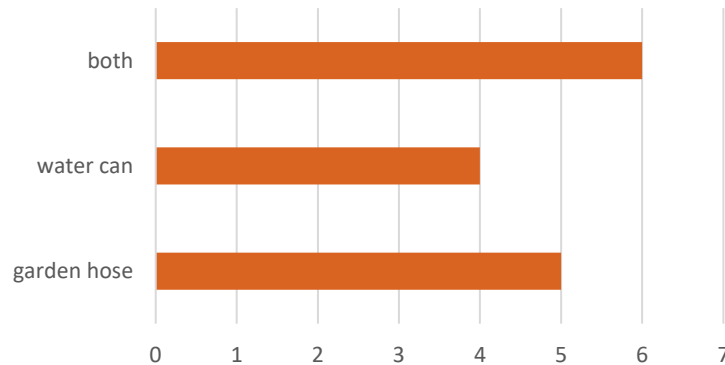
Water type used in vegetable garden
(number of participants)



Water type used for drinking
water chicken (number of
participants)



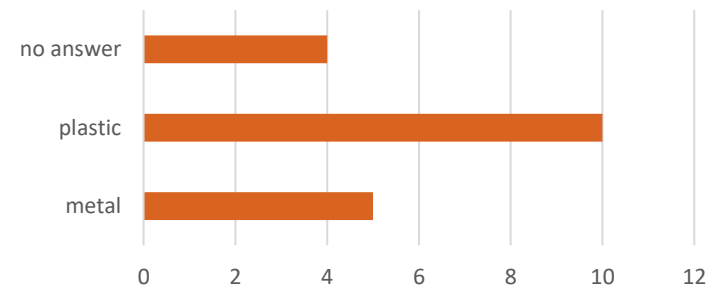
Materials used to irrigate vegetable
garden (number of participants)



Rain water: 19 participants



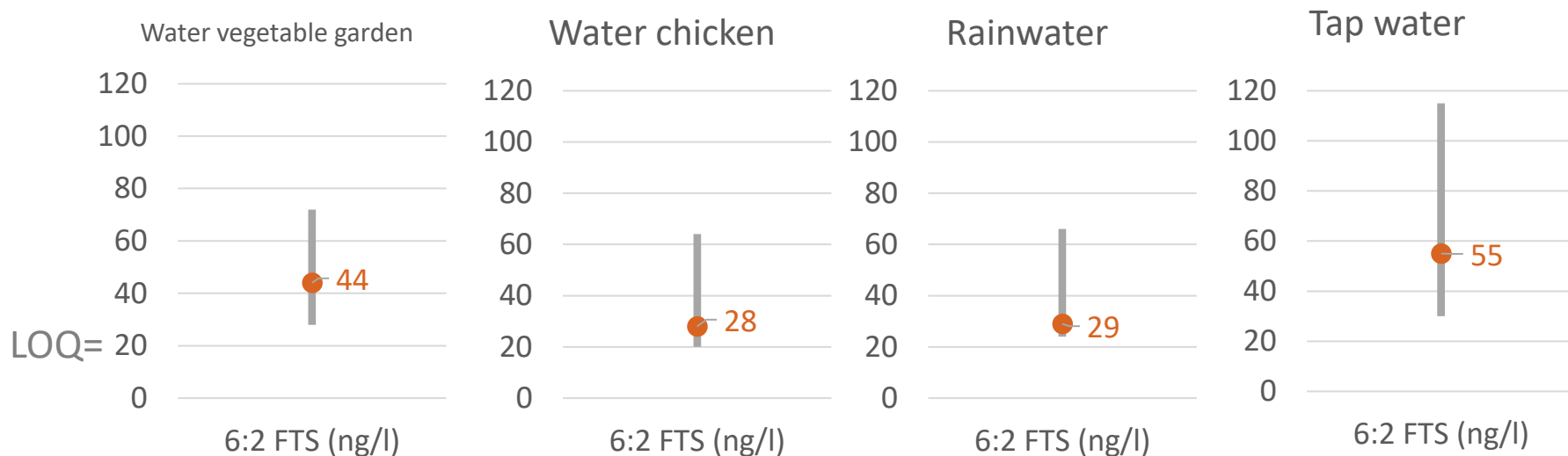
Water pipe material (number of
participants)





Results – water

► Which levels? **Median**, P25-P75



► Results higher than results VMM (2021)

→ Max: 6:2 FTS: 7,91 ng/l

→ 6 PFAS with highest level: PFBA, PFBS, PFPeA, PFHxS, PFOS, 8:2 diPAP, PFHxA



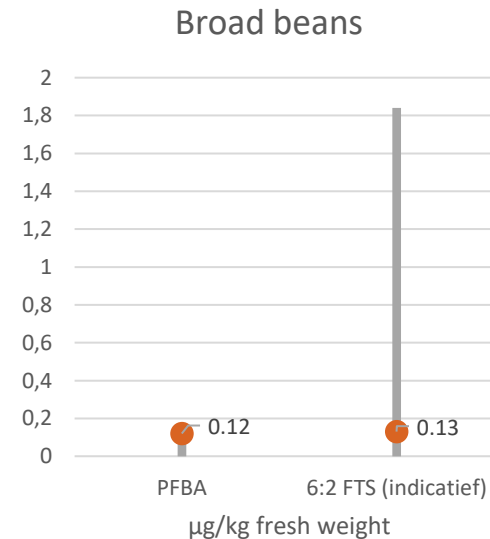
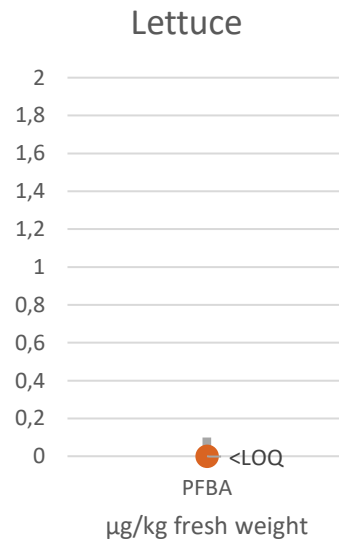


Results – vegetables

- ▶ Concentrations in vegetables very low
- ▶ Dominant PFAS: PFBA (and 6:2 FTS – indicative)
- ▶ Mostly in pods
- ▶ All PFAS <LOQ in potatoes and carrots (except 2 participants)



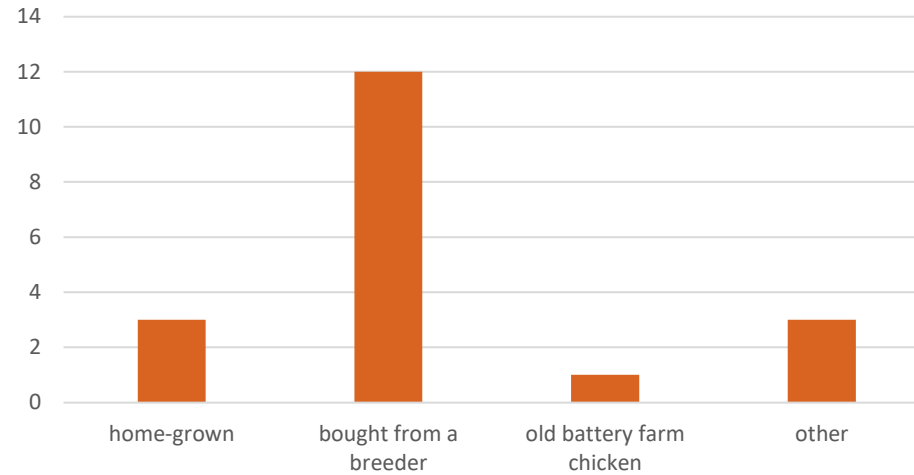
Median
P25-P75



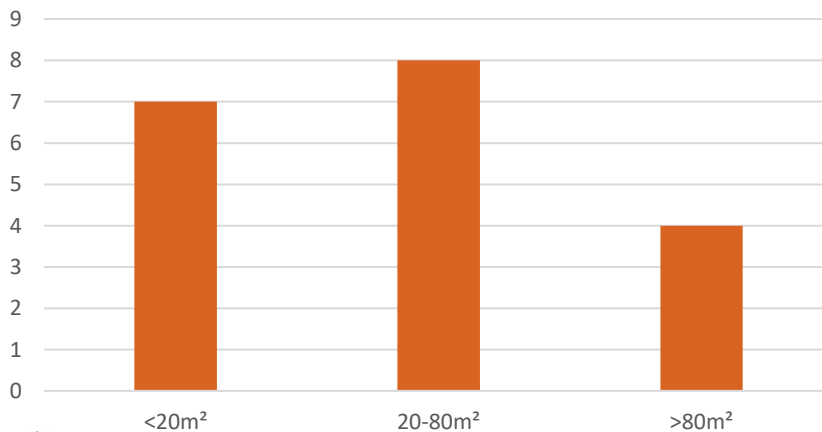


Results – eggs

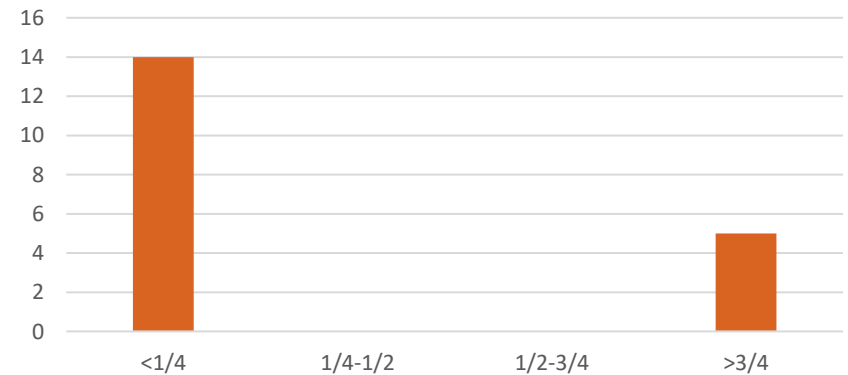
Origin (number of participants)



Free range area (number of participants)



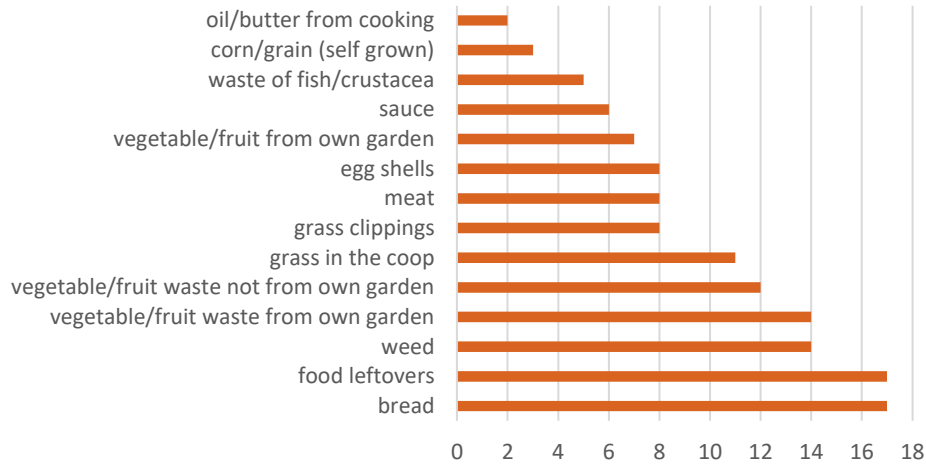
Vegetation in free range area (number of participants)



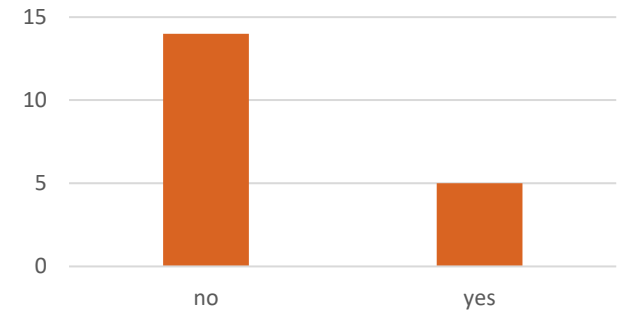


Results – eggs

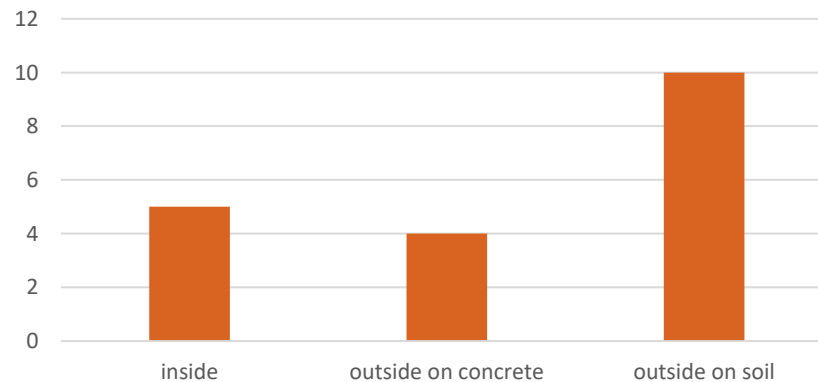
Feed for the chicken (number of participants)



Compost in chicken coop (number of participants)



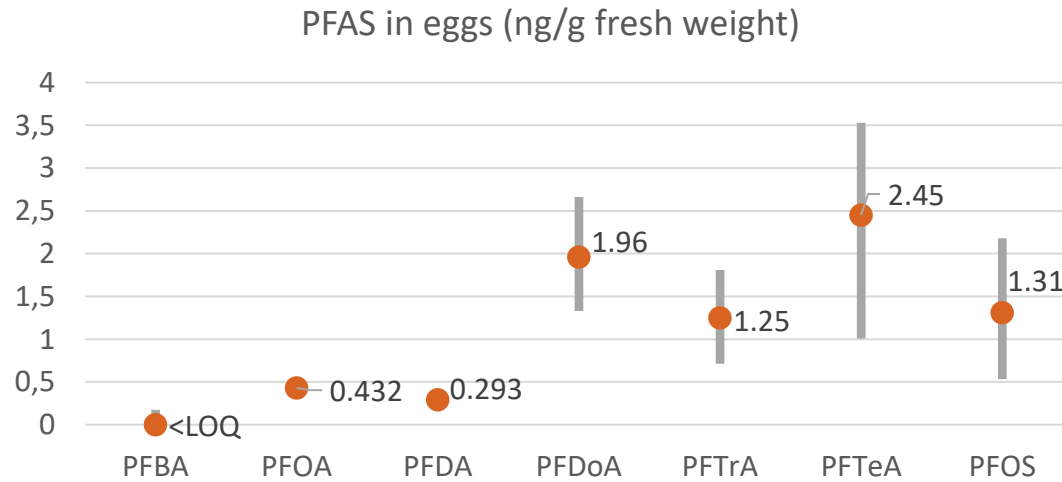
Place to feed the chicken (number of participants)





Results – eggs

► Dominant PFAS: PFTeA, PFDoA, PFOS, PFTrA

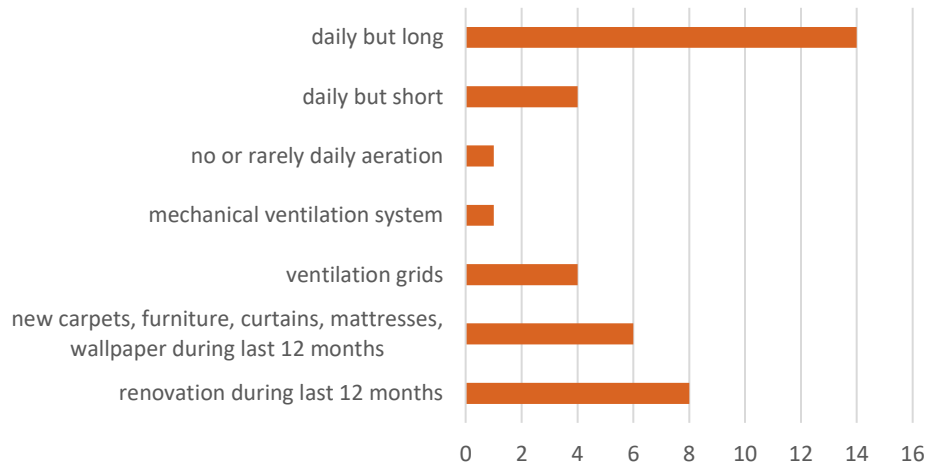


Mediaan
P25-P75

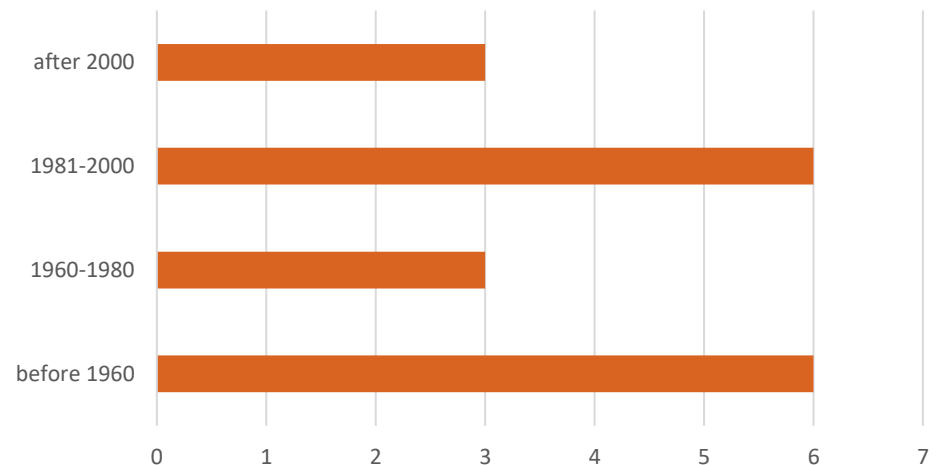


Results – house dust

House characteristics (number of participants)



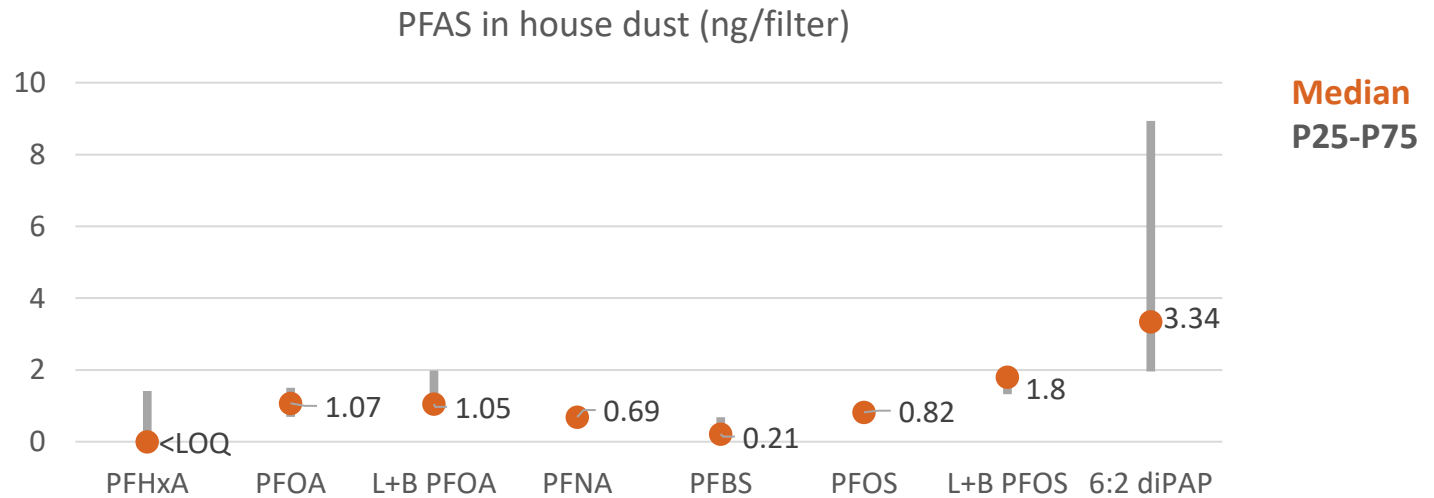
Year of construction (number of participants)





Results – house dust

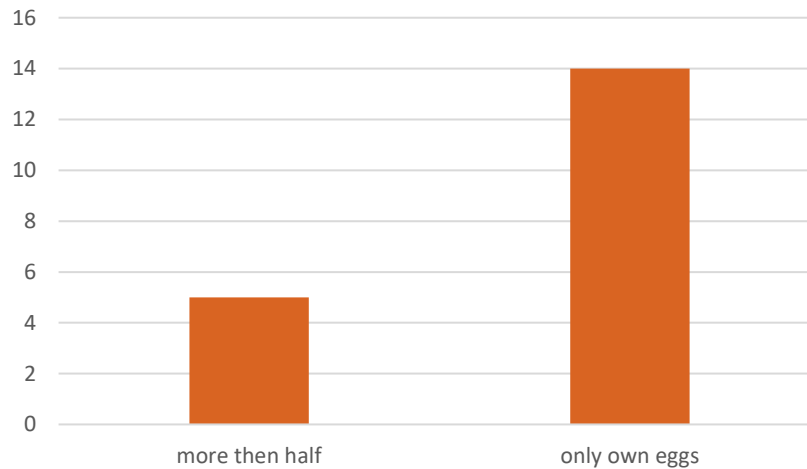
- ▶ For some PFAS uncertainty > 50% (ex 6:2 FTS)
- ▶ For some PFAS recovery of internal standard not sufficient for most of the samples
- ▶ In all samples: PFOS, L+B PFOS, 6:2 FTS, 6:2 di PAP
- ▶ In >80% of samples: PFOA, L+B PFOA, PFNA, PFDA



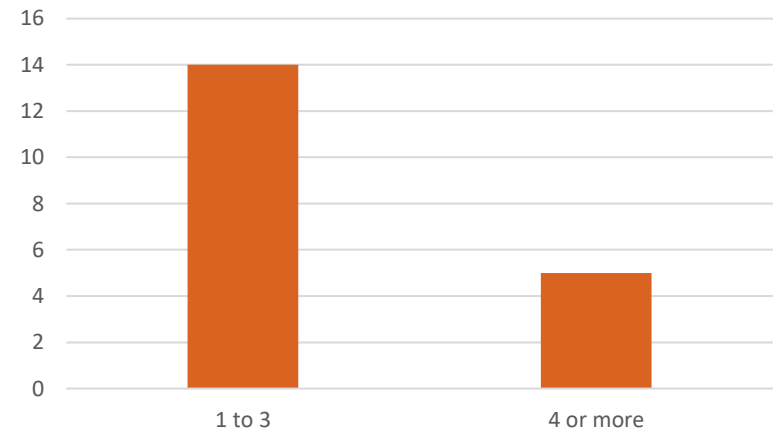


Results – blood (serum)

Proportion eggs from own chicken (number of participants)



Number of eggs from own chicken/week (number of participants)

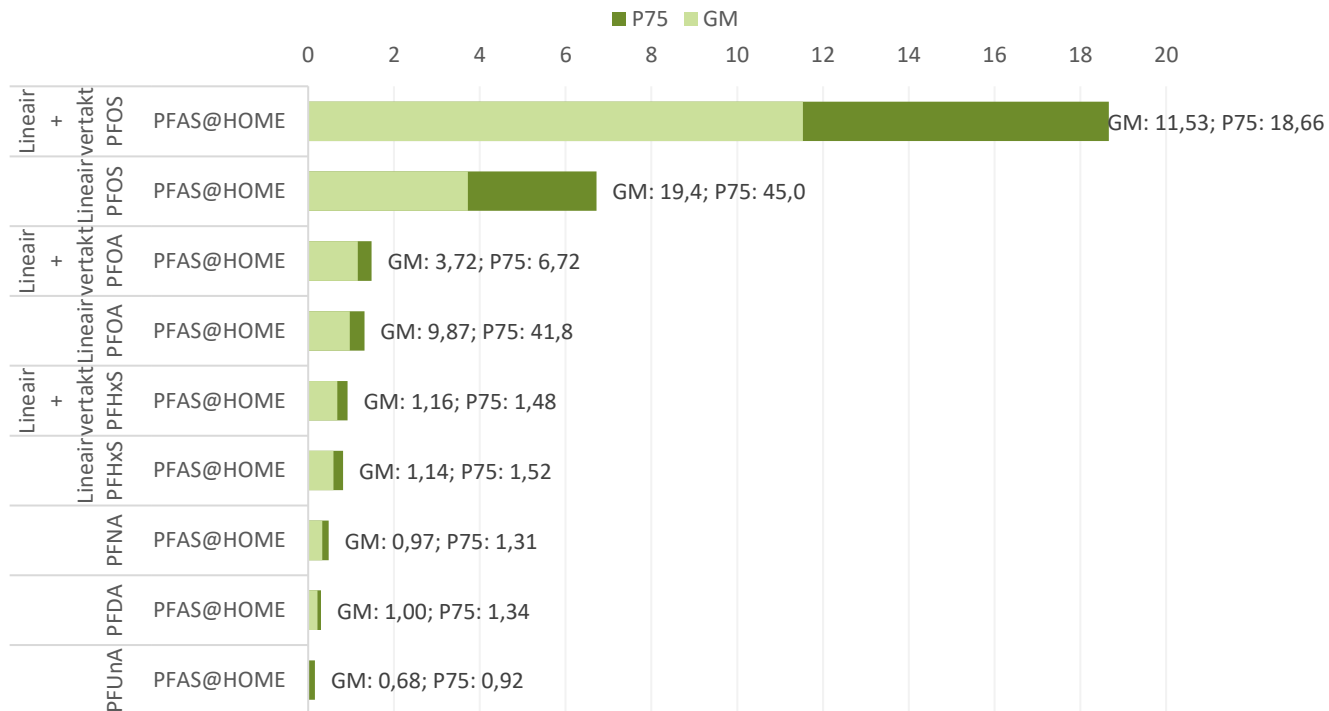




Results – blood (serum)

- ▶ **Dominant: PFOS, PFOA, PFHxS, PFNA**
- ▶ **Important proportion branched PFOS**

Geometric mean (GM) and 75th percentile (P75) in $\mu\text{g/L}$ serum for this study studie (n=19, 17-18 j)



Correlations and influence factors



LOW NUMBER OF PARTICIPANTS



- ▶ Moderate to strong correlations between PFAS in soil vegetable garden and in soil chicken coop



- ▶ No factors identified that influence PFAS in water



- ▶ No factors identified that influence PFAS in vegetables



- ▶ Moderate correlations between increasing age of the chicken and increasing concentrations PFDoA, PFTrA, PFTeA and PFOS in eggs
- ▶ Probable influence of what is thrown in chicken coop



Correlations and influence factors



LOW NUMBER OF PARTICIPANTS

▶ Higher concentrations with

- Older house (PFOS, L+B PFOS)
- Type of building materials: PVC windows, wooden ceiling (higher number of PFBA>LOQ), laminate (L+B PFOS)
- Use of products to treat leather
- Aerate manually



▶ Lower concentrations with

- Type of building materials: parquet (PFOS, L+B PFOS), tiles (PFOA, L+B PFOA, PFNA, L+B PFOS)
- Cleaning: vacuum cleaning and cleaning with water

▶ Some results are contradictory to expectations (curtains, textile threatening)

▶ Moderate correlation between PFOS in soil vegetable garden and L+B PFOS in house dust

Correlations and influence factors



LOW NUMBER OF PARTICIPANTS

- ▶ Consuming eggs seems to play a role
- ▶ Results for eating self grown vegetables unclear
- ▶ More participants with PFUnA >LOQ when using odour diffusers, insecticides, fungicides, bleach, polishers
- ▶ Some results contradictory (curtains)
- ▶ Use of tiles: lower median value for PFOA, PFNA, PFDA, PFHxS, PFOS
- ▶ Cleaning daily or more: lower media value for PFAS
- ▶ Moderate correlation between PFAS in house dust and serum





Vlaanderen
is omgeving

HBM – 3M

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Objective

▶ Objective

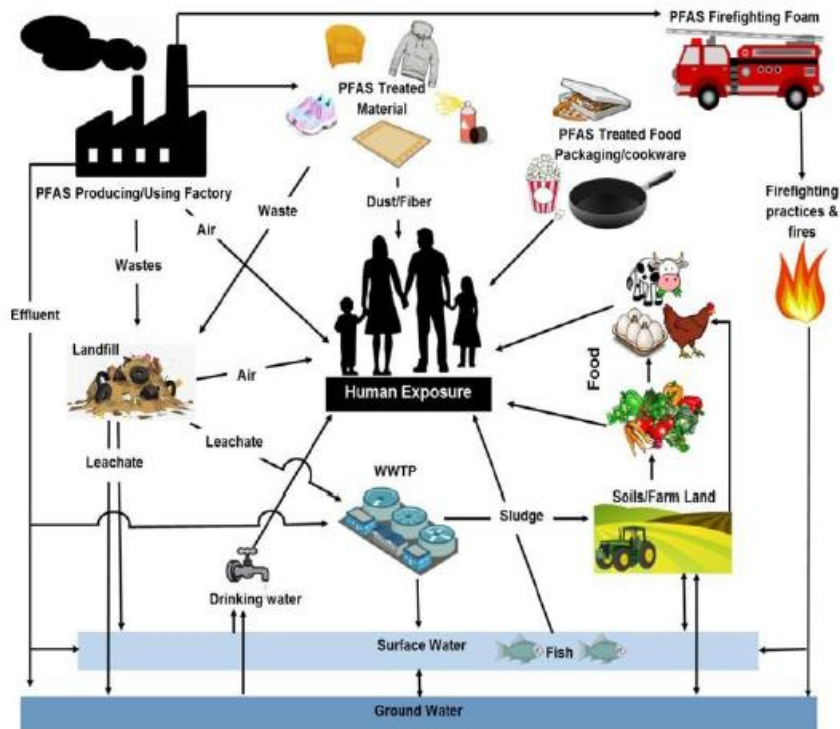
- Assess the extent to which residents in the vicinity of 3M have been exposed to PFAS
- Which health effects are present
- Identify the relative importance of different exposure pathways

▶ General approach

- Scientific study based on HBM
- Participative approach (4x local advisory board + information meetings for participants)

- Start March 2022 – end March 2023

Global approach

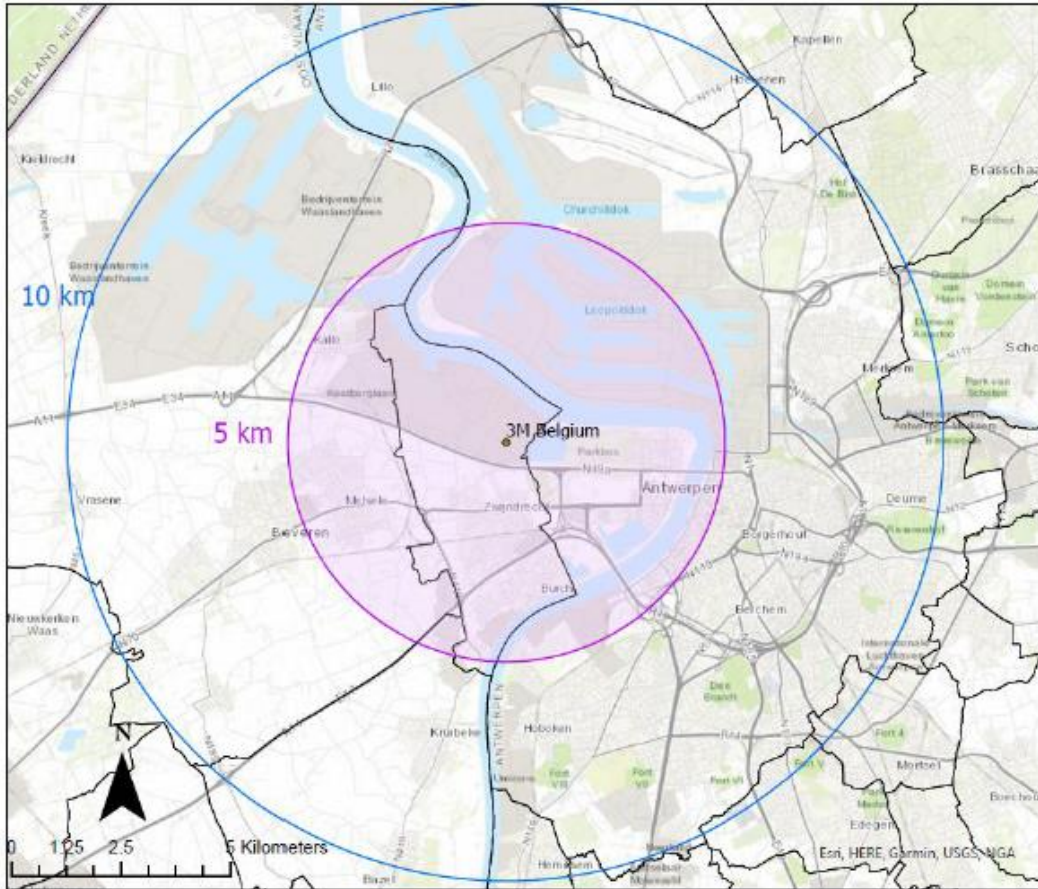


Human Exposure and sources of PFAS
Image: DWT, adapted from Ohaei et al. 2013.

- ▶ **HBM**
 - Integrated exposure
 - Markers for biological effects and/or health effects
- ▶ **Additional environmental measurements**
- ▶ **Modelling exposure routes**



Study area



- ▶ Radius of 5km around centre 3M
- ▶ Motivation
 - Situation of neighbours in the nearby environment
 - No inclusion of complex industrial context
 - Existing demarcation of 'no regret' actions



Target group and matrix

- ▶ **Adolescents 14-15 years – year of birth 2006-2009 (n=300)**
 - Half boys – half girls
 - CLB data available
 - Comparison between this study and international studies and FLEHS
 - Good reflection of local situation (living, school, hobby)
 - Limited historical exposure
 - Sensitive target group
- ▶ **Matrix: blood + serum + urine**

Measurements and questionnaires

- PFAS in serum
- Biomarkers of effect in blood, serum, urine
- Exposure via own grown food



- × Soil vegetable garden + chicken coop
 - × Eggs
 - × 4 types vegetables
 - × Compost
 - × Rain water
- Exposure via inhalation/ingestion of house dust
 - Questionnaires: personal characteristics, live style, perception, health,...
 - Biobank samples



Current situation

- ▶ **301 participants recruited**
- ▶ **Due to weather conditions during summer**
 - Problems with cultivating vegetables
 - Rainwater cistern often empty

- ▶ **Labo analysis are running**



Interpretation of results

- Determinants of exposure (geographical, life style, ...)
- Relative to reference values
- Relative to health based guidance values
- Relative to international studies
- Dose-effect relationships

- Modelling exposure routes

Policy translation

- Can insights of this study be implemented in other hot spot areas?
- Optimisation of 'no regret actions'

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