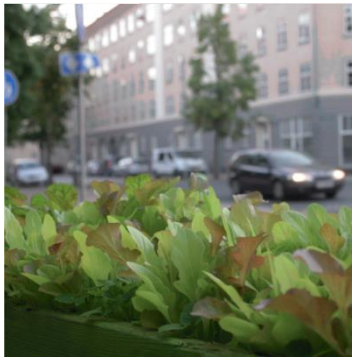
Technical University of Denmark

Uptake of chemicals into plants

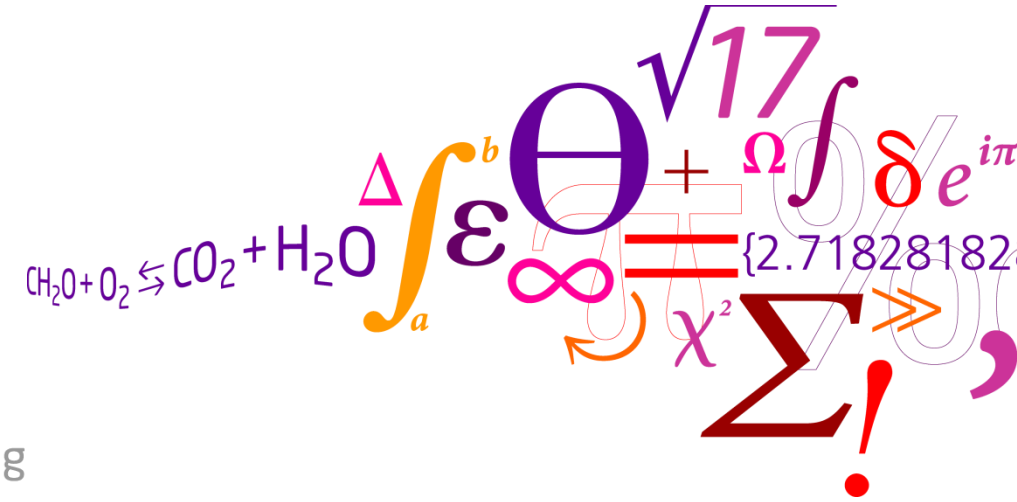
– reason for concern?




Stefan Trapp

et alii

DTU Environment
Department of Environmental Engineering



Stefan Trapp CV

1986 Diplom Geoecology

1992 PhD Botany

1998 habil Mathematics

1998 DTU assoc. Applied Ecology

2013 DTU prof. Environ. chemistry

Ecology, fate of of chemicals, models

Head of Studies of the MSc Environ Eng

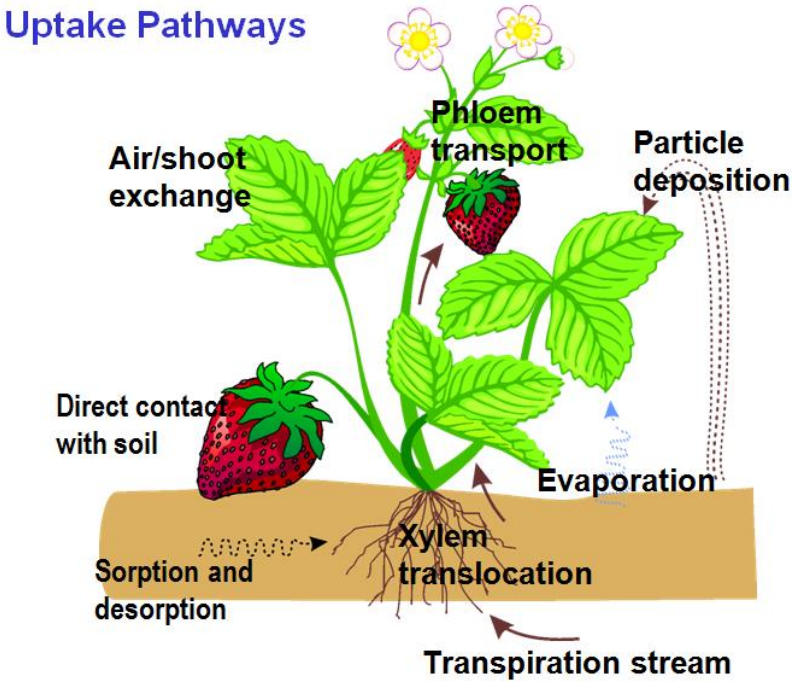
Work on plant uptake of chemicals since 1988

Three Cases

i) Heavy metals in København

ii) TCE trichloroethene in apples

iii) A new risk: perfluorinated compounds PFAA, PFOA, PFOS



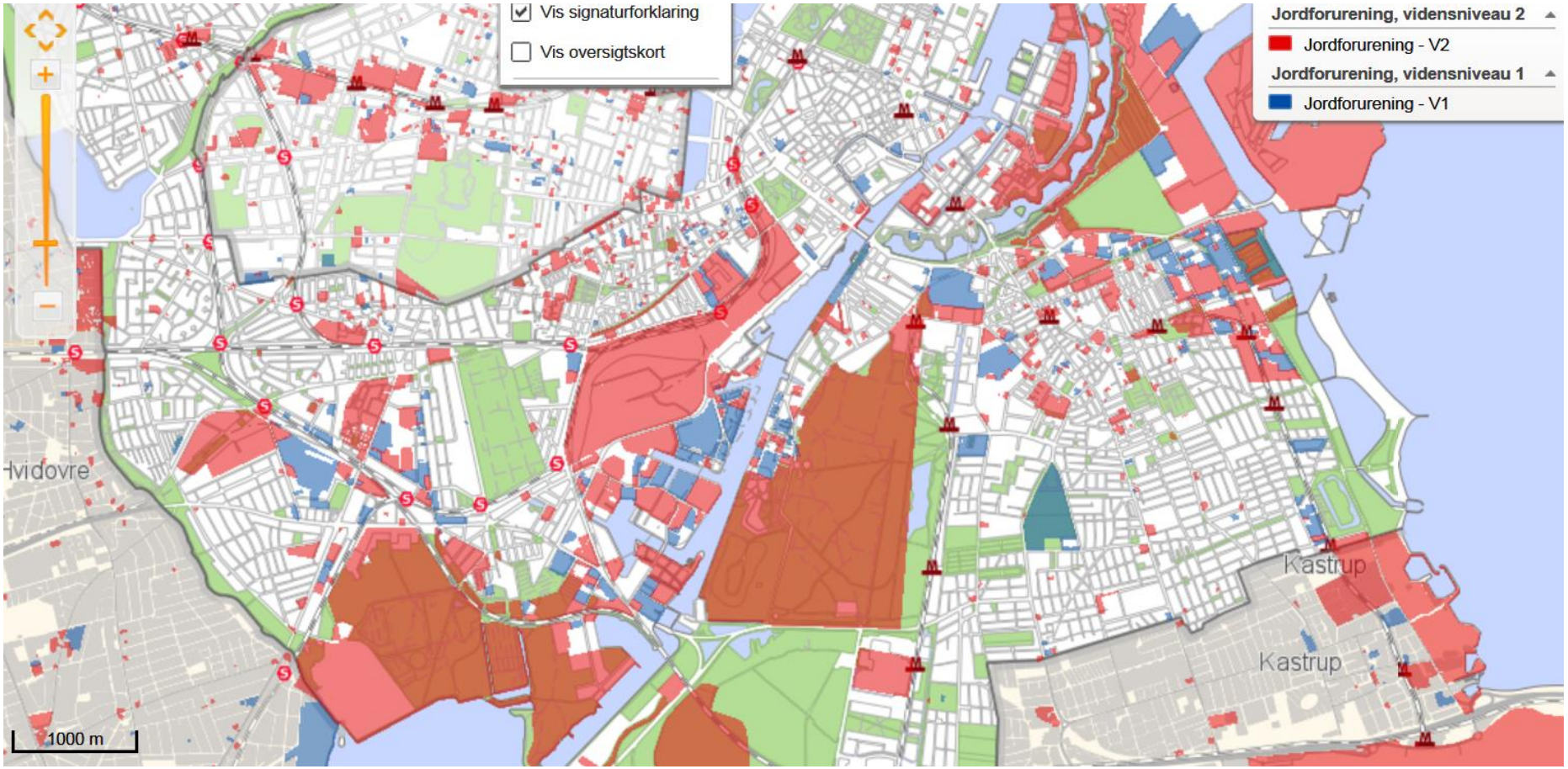
i) Heavy Metals in Copenhagen

In most if not all Western cities, people start to **grow their own** vegetables and fruits in a wave named "**Urban gardening**". People do so for sustainability, fresh and healthy food and for the joy of gardening.

Copenhagen is no exception.

Soil pollution in KH

KØBENHAVNS KOMMUNE
KØBENHAVNERKORTET



Most if not all Western city soils are **contaminated** with pollutants such as **lead** (Pb) and other heavy metals (**Cd, Cu, Cr, Ni, Zn**), arsenic (As), organic contaminants (tar, oils) and more. Paris, London, Berlin ...

Copenhagen is no exception.

Heavy metal lead Pb

Highly poisonous. Blood and brain disorder. **Cognitive deficits in children**.

Ruled out in DK since 2000 but presence in Copenhagen soils 200 to 600 mg/kg dw.

Soil quality target 40 mg/kg, intervention value 400 mg/kg

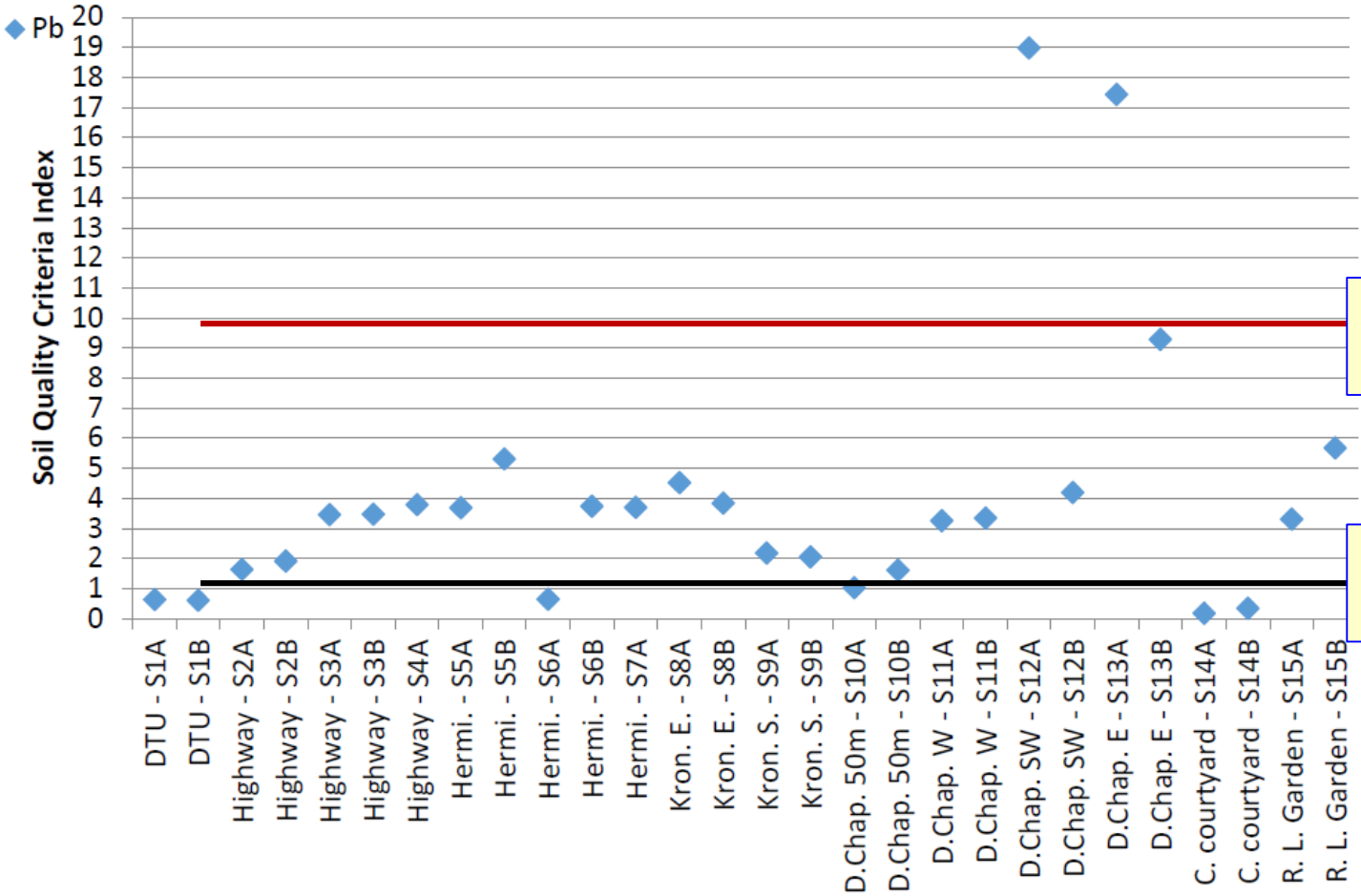
"It is appropriate to take measures to reduce the presence of lead in food as much as possible (EU 2006)."

Lead	limit µg/kg fw
Vegetables	100
Leafy vegetables	300
Green kale	300

Lead was highest 1960 to 1980 in city centers (London, Berlin) and causes slow cognitive development of children - the true reason for the punk wave?

Old roofs are a common Pb source: Dome of Roskilde.

Measured Pb concentration in top soils KH and område public parks (times soil quality standard 40 mg/kg dw)



intervention value 400 mg/kg

soil quality goal 40 mg/kg

Figure 11: Soil Quality Criteria Index for Pb.

source: Nikolo Pekeč, MSc thesis 2017

Project “Risks of Urban Gardening”

Facts

KH Kommune Teknik- og Miljøforvaltning contacted DTU, and our students grew and analyzed vegetables and fruits for their heavy metal content.

Questions

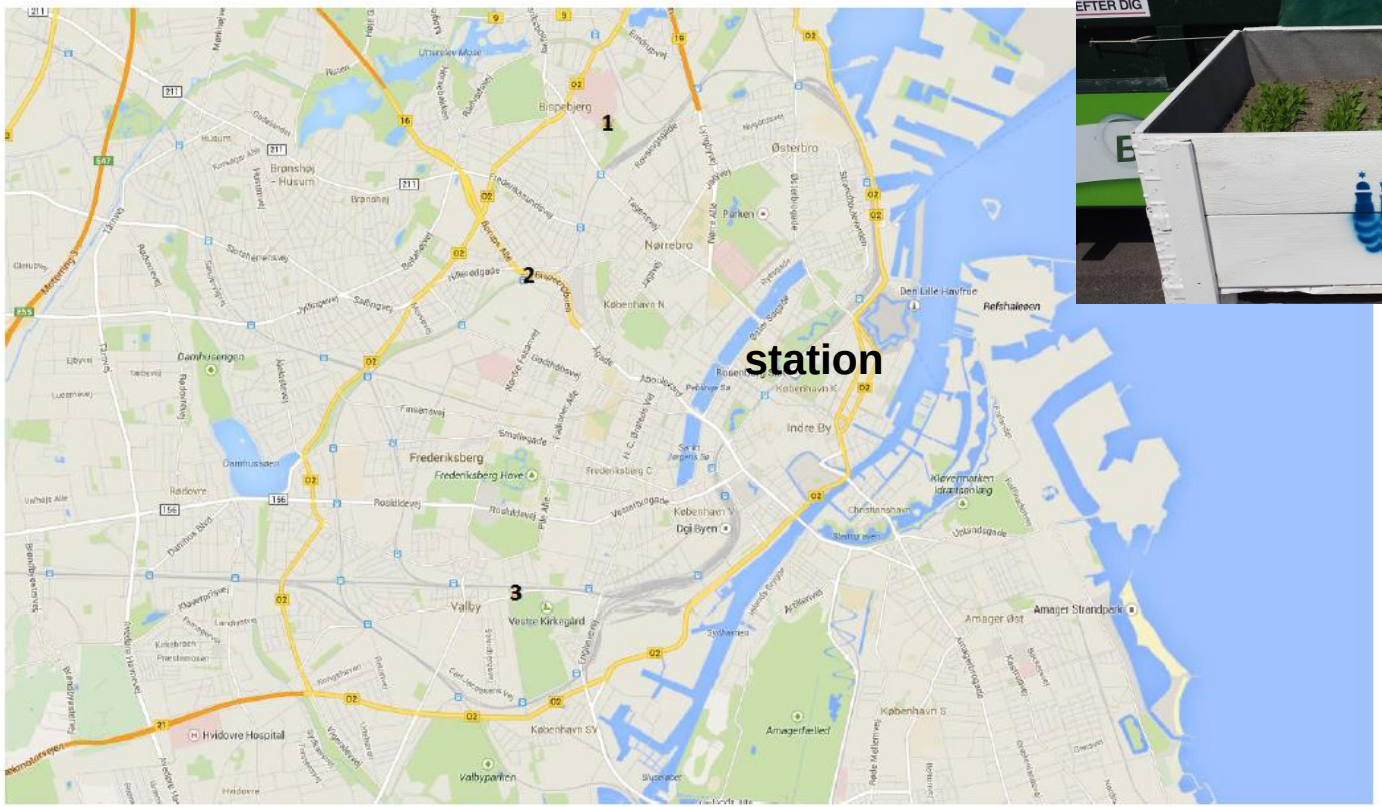
- Is it hazardous to do Urban Gardening in KH?
- Do the harvest products contain heavy metals at risky levels?
- Do the harvest products contain heavy metals above legal standards?

All data shown are from student projects.

Campaign 2014 Martin Bjerge Jørgensen

Radish, spinach, lettuce grown **in containers**

Down-town but **with clean soil**. Uptake from **air**.



Campaign 2014

Martin B. Jørgensen

Downtown but in clean soil
= uptake from **air**

Measured concentrations, fresh weight.
In brackets: legal standards.

	Lead	**Cadmium**
Soil mg/kg dw	14 to 31 (40 / 400)	0.08 to 0.27 (0.5)
Lettuce µg/kg fw	26 to 69 (300)	21 to 68 (200)
Spinach	28 to 51 (300)	55 to 145 (200)
Radish	6 to 9 (100)	3 to 6 (100)

Growing plants in clean soil down-town Copenhagen gave vegetables with **no reason for concern**.

It can also be concluded that air pollution in Copenhagen is no obstacle for urban gardening.

Campaign 2012/13

Marlies Warming
and Mette Guldborg Hansen

Gardening **in local soil**

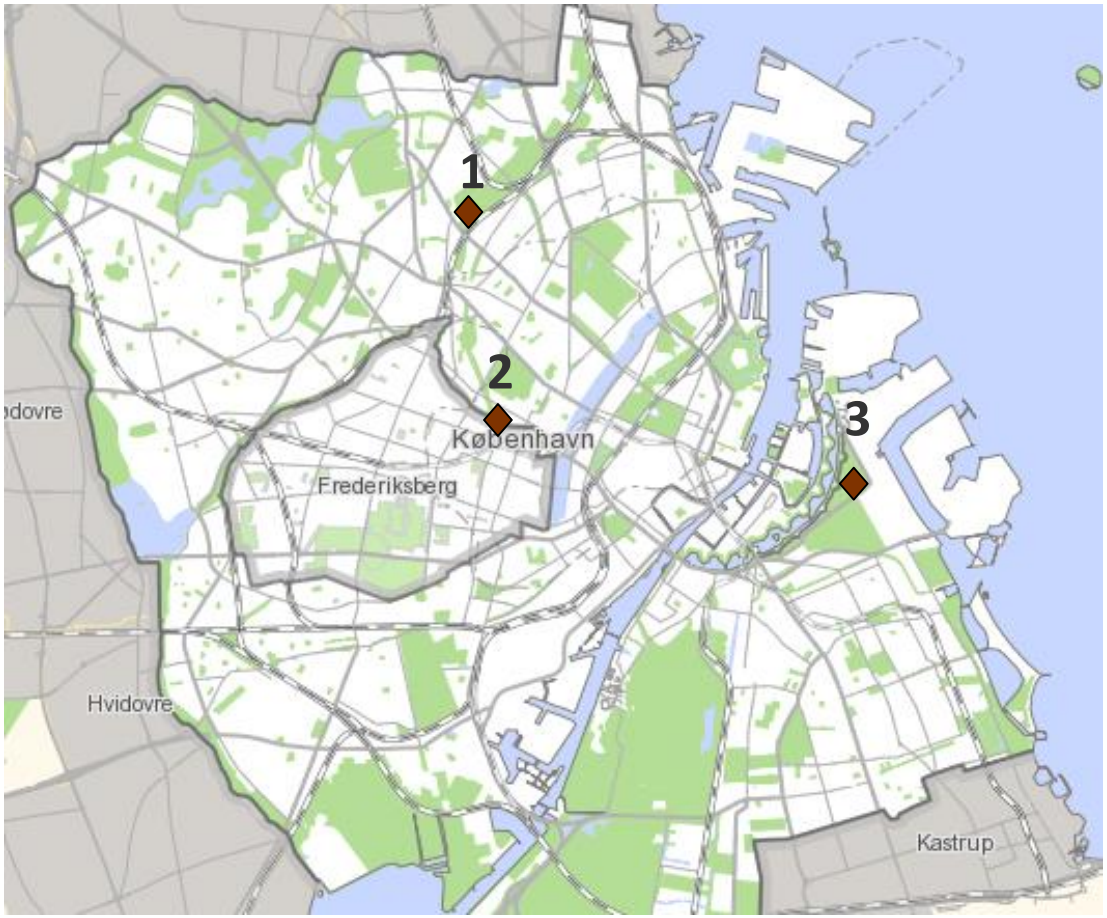
Does intake of trace elements through urban gardening in Copenhagen pose a risk to human health?

Marlies Warming [a], Mette G. Hansen [a, *], Peter E. Holm [a], Jakob Magid [a], Thomas H. Hansen [a], Stefan Trapp [b]

[a] Department of Plant and Environmental Sciences, Faculty of Science, University of Copenhagen, Thorvaldsensvej 40, 1871 Frederiksberg C, Denmark
[b] Department of Environmental Engineering, Technical University of Denmark, Miljoevej 113, 2800 Kongens Lyngby, Denmark

Environmental Pollution 202 (2015) 17–23

Campain 2012/13 Sampling sites



Sampling sites in Copenhagen (map from kbh.kort.dk).

- Soil samples
- Vegetable samples

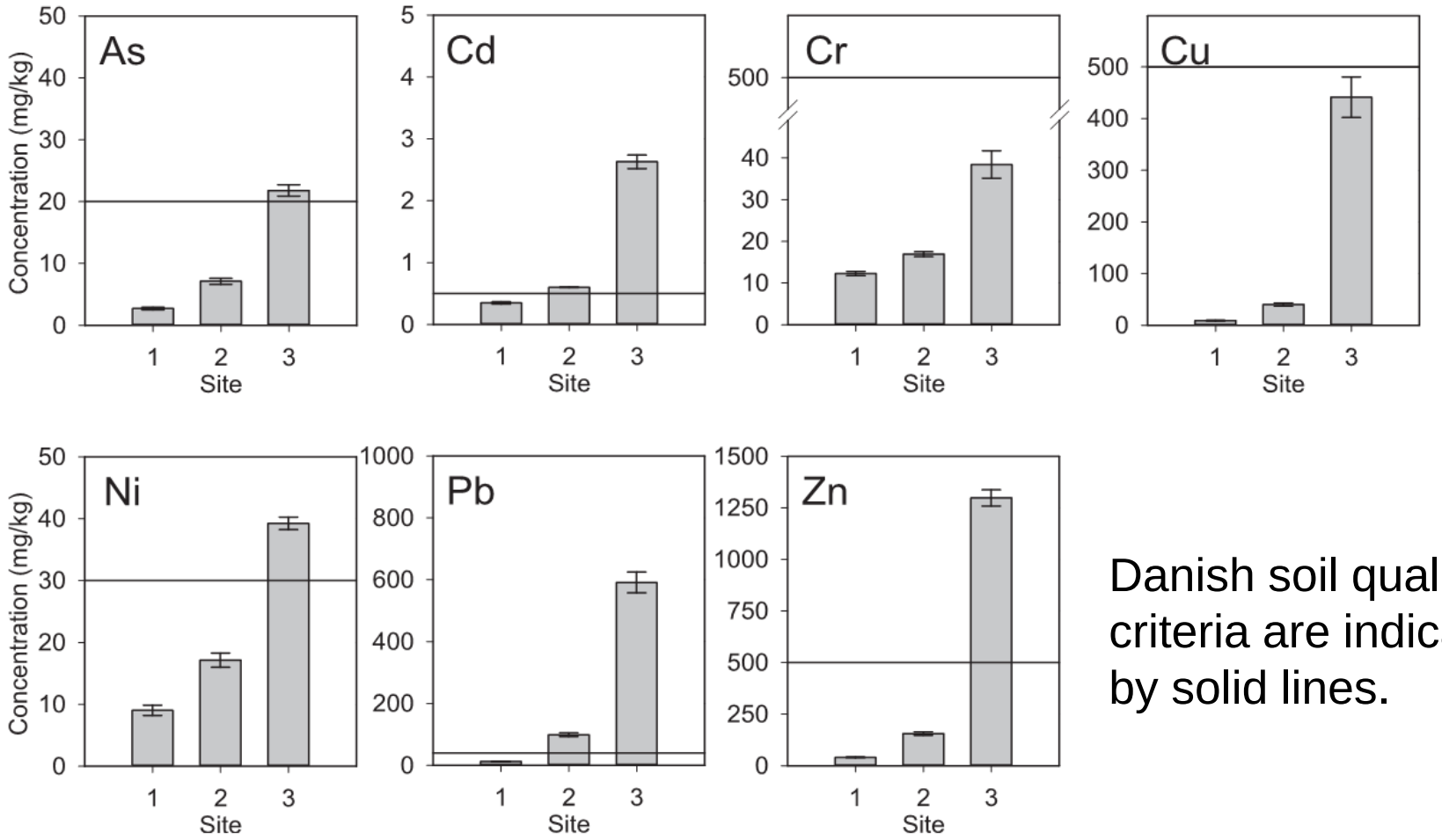
1 noname garden

2 KU SCIENCE student gardens

3 Strandlyst allotment gardens

Concentrations in soil (mg/kg dw)

1 = low 2 = medium 3 = above legal standard for As, Cd, Ni, Pb, Zn



Danish soil quality criteria are indicated by solid lines.

Concentrations in vegetables (mg/kg dw)

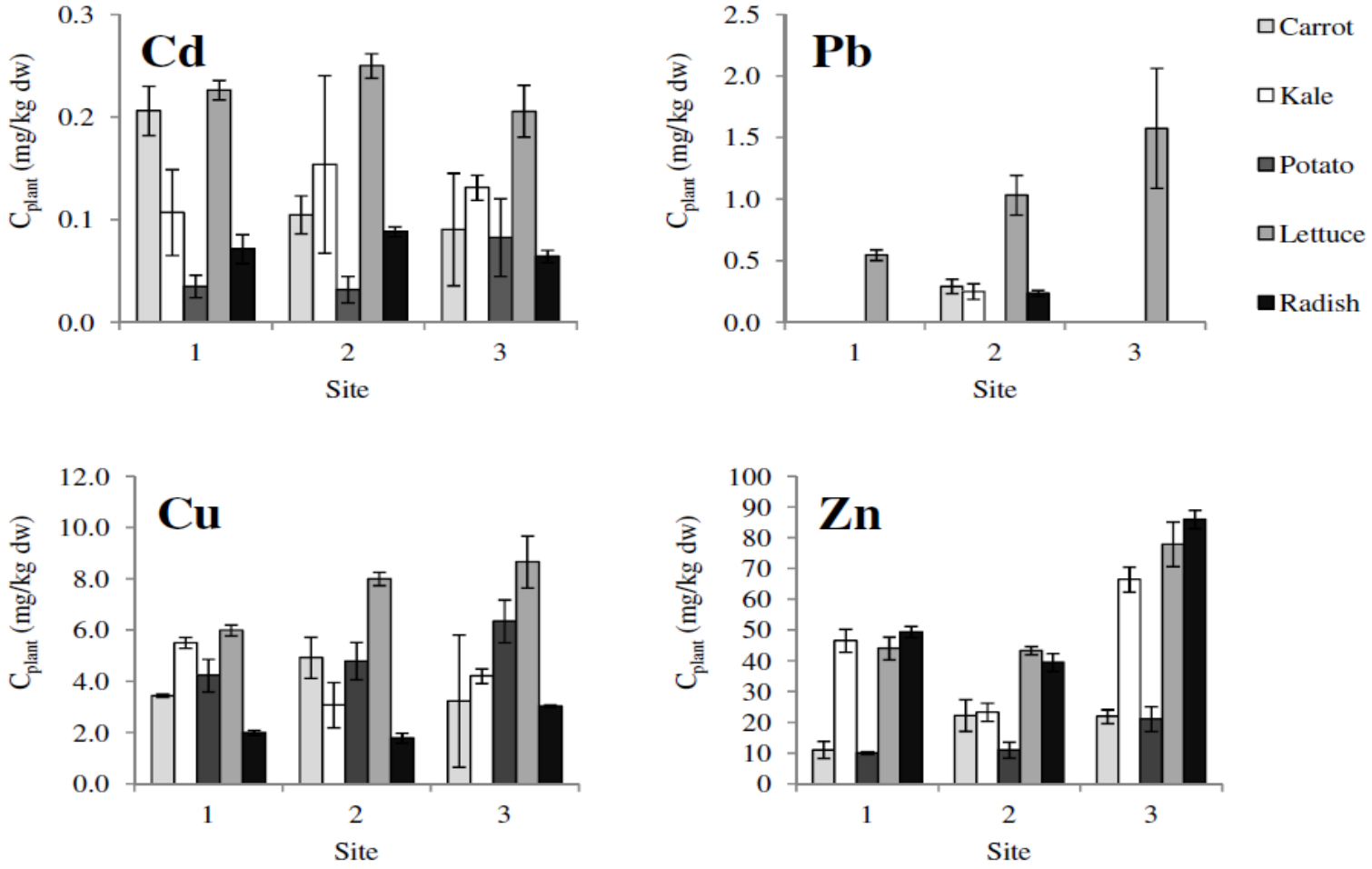
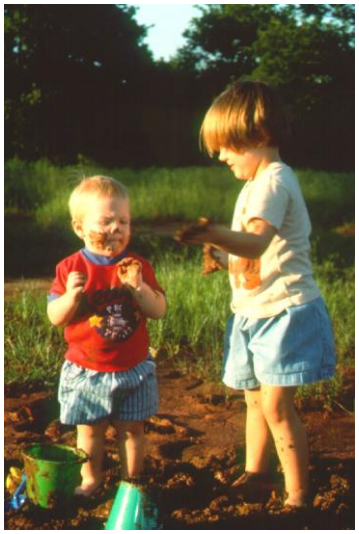


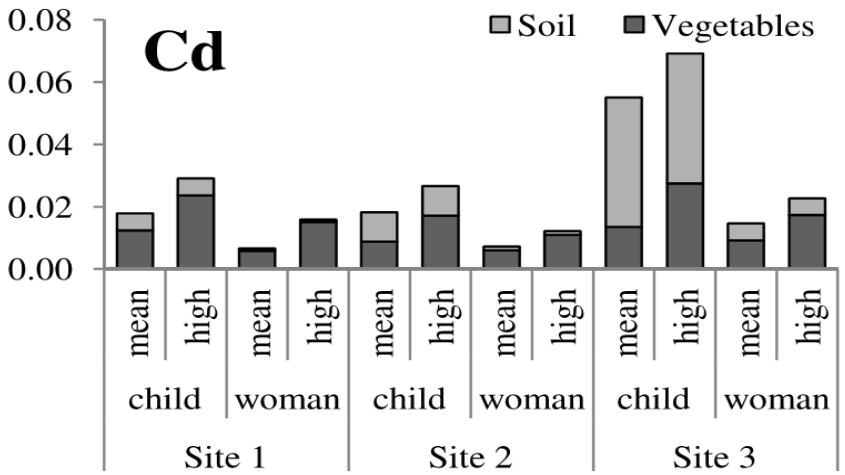
Figure 12. Trace metal concentrations in the vegetables. Concentrations of Cd, Cu and Zn are derived from analysis with ICP-OES, while Pb concentrations originate from analysis with GF-AAS. Error bars indicate 95% confidence intervals (n = 3, if the vegetable was only present at 1 subsite, or n = 6, if the vegetable was present at 2 subsites, compare section 3.1.1).

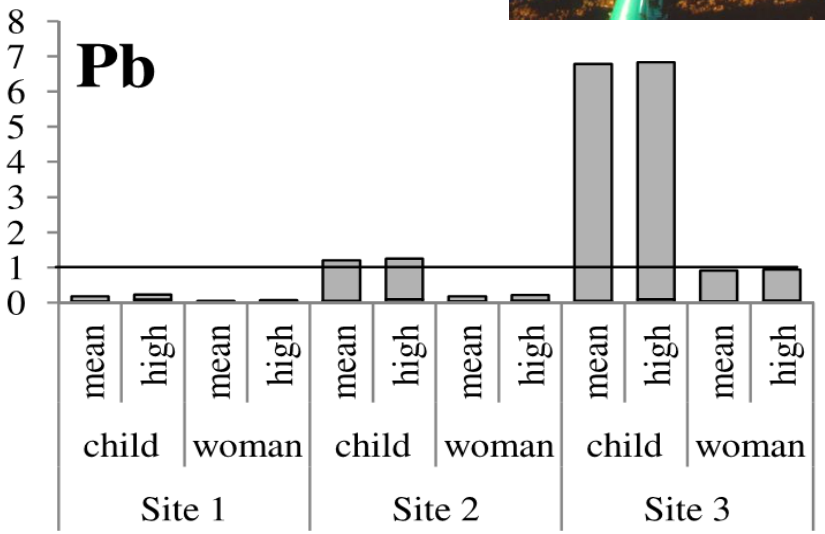
Risk assessment

Ratio of intake to tolerable daily intake.

Vegetable consumption (Danish average) and
direct soil ingestion (200 mg/d children, 50 mg/d grown-ups).







The risk in KH (if any) is not the food from contaminated sites - it is **intake of soil attached to vegetables and by playing children!**

Lead in vegetables - urban gardens and commercial

Concentrations in µg/kg ww

Pb	**Urban produce[a]**			**"normal" food**		**EU limit[c]**
	n	mean	min - max	*n*	min - max	
Carrot	*4*	24	12 - 35	*24*	3 – 37	100
Radish	*3*	22	11 – 38	*5*	10 – 40	100
Potato[d]	*5*	17	8 – 33	*143*	0 – 39	100
Lettuce	*3*	54	28 – 78	*10*	5 – 61	300
Kale	*4*	39	23 – 63	*23*	26 – 164	300

[a] Values from Hansen and Warming (2013) and Jørgensen (2014)
[b] Food database of Denmark http://frida.fooddata.dk
[c] Limit values according to Commission regulation EC No. 1881/2006
[d] Potatoes analyzed with peel, EU limit value for potato without peel

Conclusions and recommendations

Heavy metals København

We found that **lead** is the most problematic **heavy metal** in KH soils.

All concentrations in vegetables were **below legal standards** and **not higher** than in commercial products.

Most **lead** is taken up with attached soil, or by **direct soil ingestion**.

Thus: wash your hands; wash and peel your vegetables; if possible, use clean soil in containers for gardening downtown.

Reference: Warming, M., Hansen, M.G., Holm, P.E., Magid, J., Hansen, T.H., Trapp, S. (2015). Does intake of trace elements through urban gardening in Copenhagen pose a risk to human health? Environmental Pollution 202, 17-23.

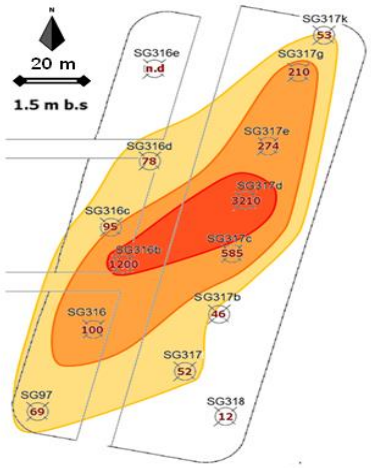
ii) TCE Trichloroethylene in fruits

Own studies: Wood samples to screen for GW contamination – very successful, often TCE

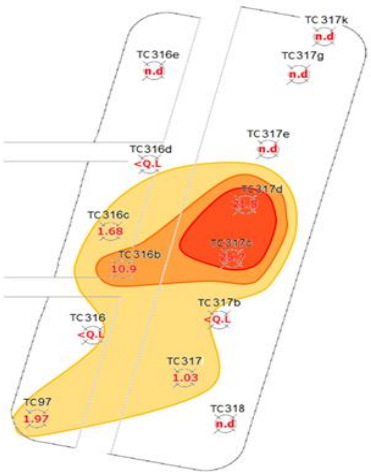
We never found TCE in fruits
and only small amounts in leaves**.**

Is there a health risk from TCE plant uptake?

Soil gas sampling



Tree coring



Det koster det samme at lave fire almindelige boreprøver, som at lave de 38 træ-prøver, der blev taget i Maribo i søndags

Mod et lille bor bliver der taget en prøve fra træets indre. Den kan afsløre eventuel forurening i undergrunden. FOTO: PER KJÆRGÅRD

Ny metode kan afsløre forureninger i grundvandet

Afslørende træ-prop

MARIBO Et lille bor, bliver banket ind i et træ - og langsomt drejes en lille prop ud. En prop der kan afsløre, hvordan sundheden har det lige på dette sted i Maribo.

Ansatte fra Region Sjællands jordforureningsteam var søndag i Maribo, hvor man sammen med civilingeniør Mette Algreen Nielsen fra virksomheden "Screening by green" lavede en ny undersøgelse af grundvandet.

Metoden med at bore en prop ud af træerne er nemlig helt ny i Danmark, og kan forholdsvist billigt afsløre, hvordan gammel forurening spreder sig.

I Maribo var det området omkring vaskeriet og en tidligere maskinfabrik, der blev undersøgt. Her har regionen en bekræftet mistanke om, at flere virksomheder kan have forurenet med rensevæsker for op mod 50 år siden.

- Dengang var det typisk, at man blot hældte rensevæsker i kloakken eller smed dem ud på jorden bag bygningen, fortæller teamleder Henrik Jannerup fra Region Sjælland.

Området omkring Magleværvej, Victor Kolbyesvej og Valdemar Henriksensvej er derfor udvalgt til at afprøve metoden med træprøver. Det er nemlig så stort, at det ville være dyrt at lave egentlige boringer på alle matrikler.

Den nye metode er brugt i USA, men i Danmark er der ikke gjort mange forsøg. Viser prøverne fra Maribo at være en succes, så kan det dog ændre sig.

- Denne metode er velegnet som en pre-screening. Men selv om man ikke måler forurening i træerne, kan den sagtens være i jorden. Det afhænger blandt andet af, hvor dybt rødderne når ned, forklarer Mette Algreen Nielsen.

Samtidig er det ikke alle stoffer, der kan måles med denne metode.

- Eksempelvis er det ikke uden videre muligt at måle for tungmetaller, da de findes naturligt i naturen. Måler vi tilgængeligt nogle af disse organiske stoffer, som vi ved, vi kan søge efter, så er det fordi, at grunden er forurenet, forklarer Mette Algreen Nielsen.

I alt tog man 38 prøver i Maribo, og om godt 14 dage vil de være analyseret. Herefter er det op til Region Sjælland, hvordan de videre undersøgelser skal forløbe. Det handler alt sammen om, hvor alvorlig forureningen kan være.

- Det handler om at vurdere, hvor stor en eventuel forurening er, og hvor stor risikoen er omkring vores grundvand, forklarer Henrik Jannerup.

I Region Sjælland håber man, at træ-prøverne viser sig brugbare, så metoden i fremtiden kan bruges, når der skal pre-screenes for jordforureninger et sted i regionen.

Mette Algreen Nielsen viser her én af de 38 træ-prøver, der blev taget i Maribo i søndags. FOTO: PER KJÆRGÅRD

FALLE NEVAD FRANDSEN

Uptake and transfer of TCE to fruits

William Doucette ("Bill")

presented at DTU, course 12906, year 2013, 2015

Hilltop Times

■ Hill AFB, Utah 84056-5824 www.hilltoptimes.com hilltop.pa@hill.af.mil Vol. 57 No. 40, October 11, 2001 ■

GDEN ALC

NSIDE:

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FC begins
Page 2

■

discrimination
Page 3

TCE found in local fruit tree samples

by Charles Freeman
Enviromental Public Affairs

Results from a recent Hill AFB sponsored study show traces of TCE (Trichloroethene) in homegrown fruit from selected fruit trees sampled in Sunset and Clinton.

In August and September, Utah State University scientists – at Hill's request – sampled fruit trees and vegetable gardens for possible contamination and discovered small traces of the chemical in the fruit samples. Hill environmental officials believe this could be the first time TCE has ever been detected in homegrown fruits.

Hill officials did the study after they were approached by residents who attended environmental-sponsored InfoFairs held last fall in Sunset and Clinton. At that time, nine residents asked environmental personnel to sample their fruit trees and vegetable gardens for possible contamination.

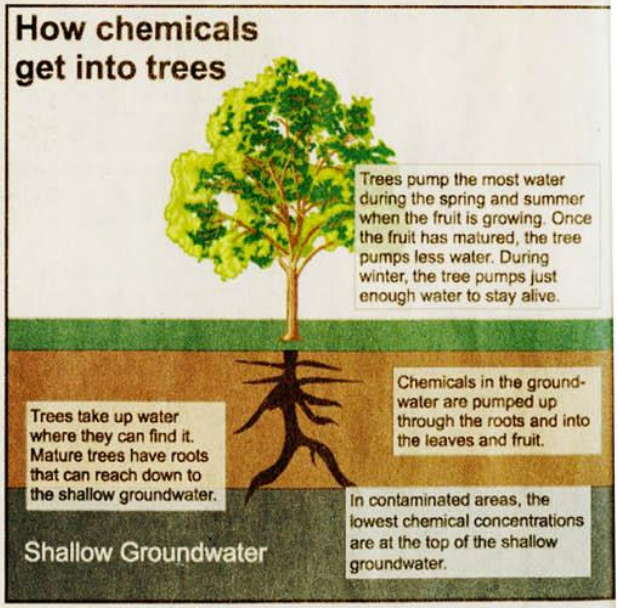
Extremely low traces of TCE were found in trees belonging to seven of the nine residents. There was no detection of TCE in fruit at the property of the other two residents. In addition, the study showed no such contamination in vegetable gardens sampled in the same areas.

During the last few years community outreach efforts have been stepped up considerably by Hill's environmental staff. The InfoFairs provide an opportunity for people in the surrounding areas, impacted by the groundwater contamination, to get pertinent information on Hill's cleanup program.

TCE is a degreasing solvent commonly used at Hill AFB until the mid-1970s and is the most common groundwater contaminant at Hill. According to published information, TCE is suspected of causing cancer in animals, but its effects on humans, especially at low levels, isn't known.

"The sample results came as a complete surprise to us," said Allan Dalpias, the base's director of Environmental Management. "When the first set of sampling results arrived in late August, our first inclination was that there was probably a mistake somewhere." A second set of samples

■ *See* **Fruit,** *page 5*



Newsmaker

Roche outlines

Summary of field survey results (µg/kg fw)

Sample type	Total samples[a] (Year 1)	Detects above MDL[b]	Total samples (Year 2)	Detects above MDL	Total samples (Year 3)	Detects above MDL
Fruit	103	15 (0.4 - 17.9)	257	0	149	0
Trunk cores	64	13 (0.4 to 7.5)	58	10 (0.6 to 62)	264	93 (0.4 to 204)
Total	167	28	315	10	413	93

[a]17 locations in year 1, 31 in yr 2, and 5 in yr 3. Replicates included.

[b]0.1 ug/kg fresh weight

Hypothesis

TCE

(glycoside metabolite, trichloroethanol)

Phloem

Volatilization

TCE

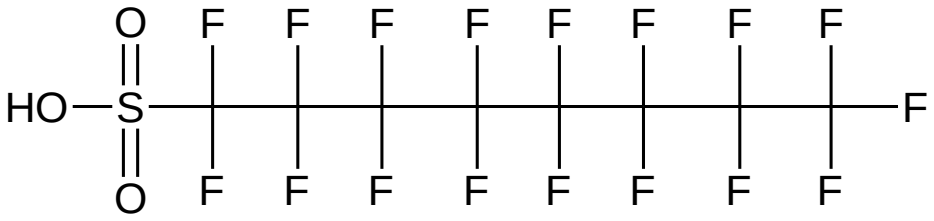
Xylem

TCE

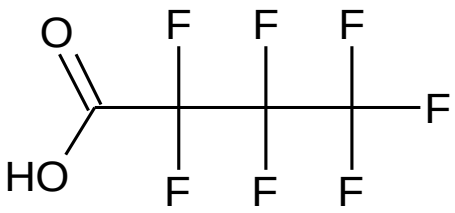
Very little risk of TCE (and PCE, DCE, VC) accumulation in fruits due to rapid **volatilisation**.

iii) Perfluoroalkyl acids PFAA

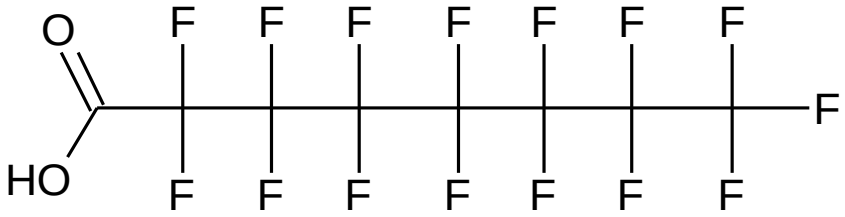
About **4000** perfluorinated compounds in use (!) for pizza boxes, fire foams, impregnation, who-knows-what. **Very stable**. Hydrophobic and lipophobic (film-forming). **Bioaccumulative and persistent**!



PFOS Perfluorooctane sulfonic acid



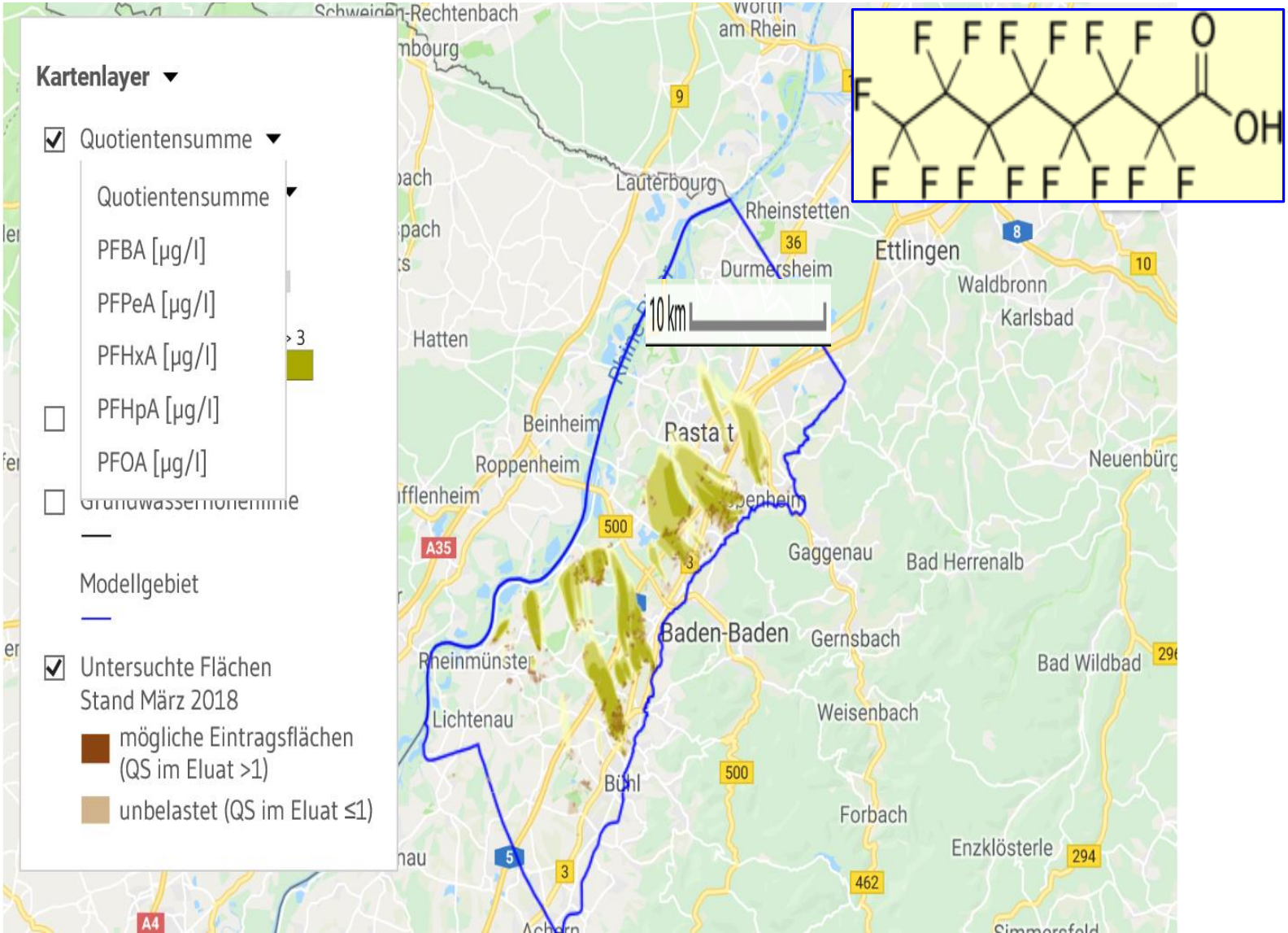
PFBA Perfluorobutanoic acid



PFOA Perfluorooctanoic acid

Example: Germanys best vegetable land – 644 ha

contaminated by **polyfluorinated compounds** in recycled paper compost



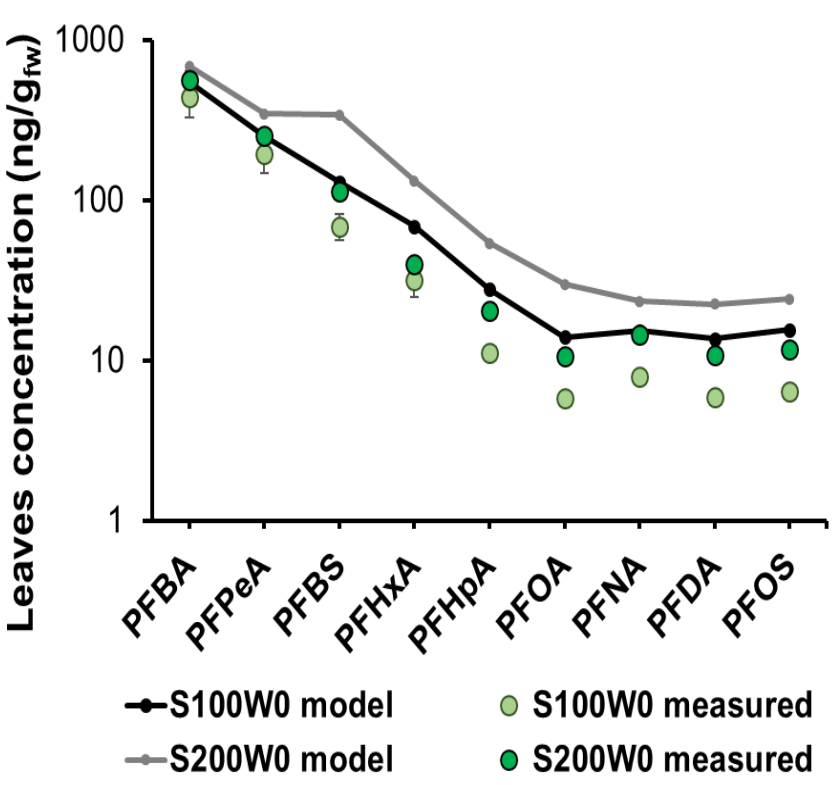
Study on plant uptake of PFAA

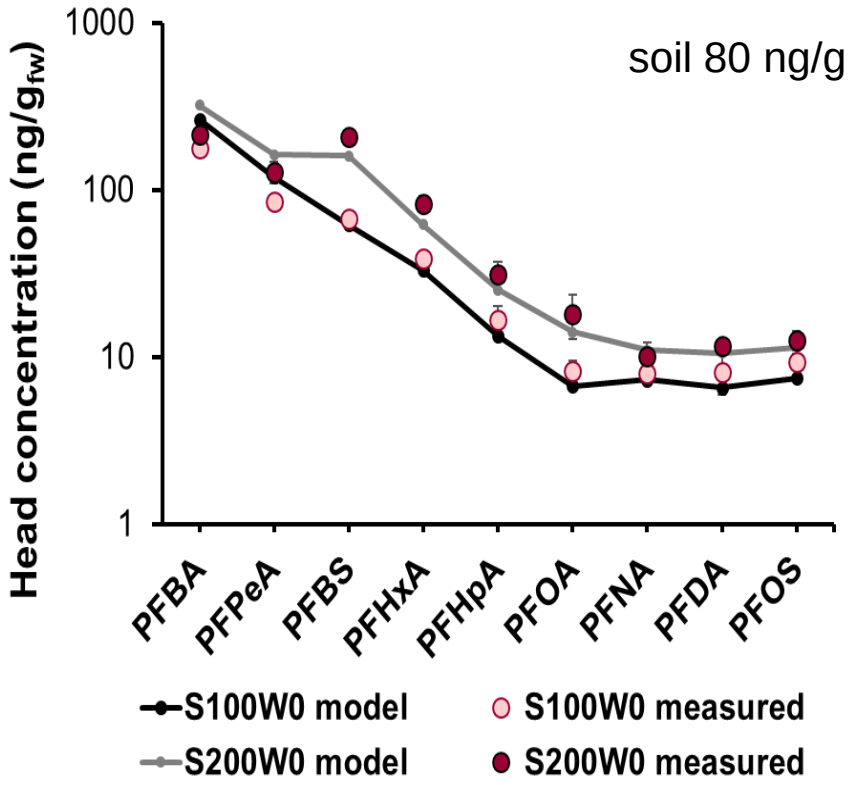
Andrea Gredelj, guest PhD at DTU in 2019

Chicory exposed to 9 PFAA in soil and irrigation water for 81 days

Study on plant uptake of PFAA

Chicory data Andrea Gredelj, model Andrea & Stefan 2019



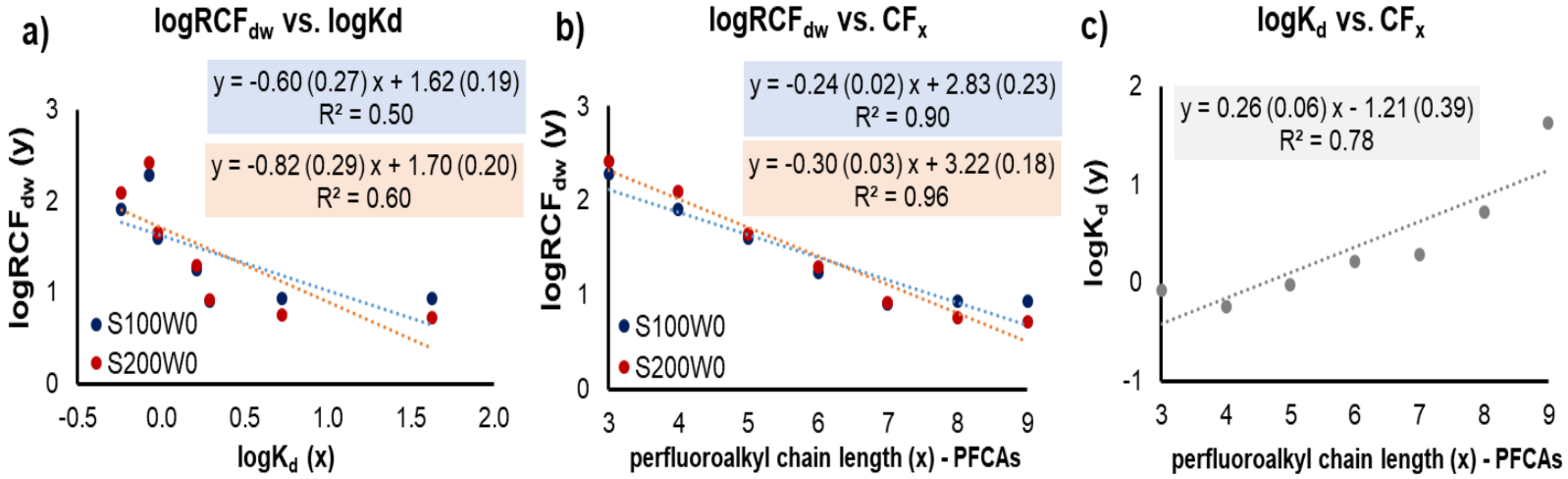


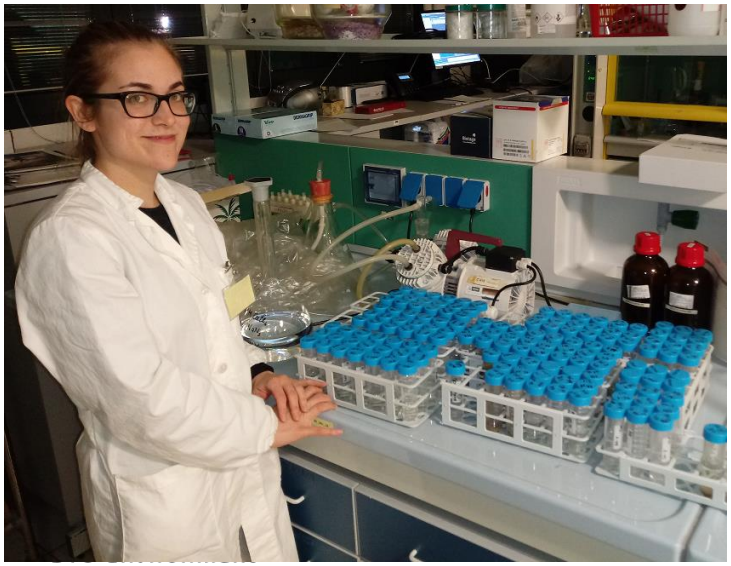
High accumulation from soil in plants **of short** PFAA

those are so far not considered bioaccumulative (in fish, milk, meat)

No regulation, little attention – take care!

Results plant uptake of PFAA





Short-chain PFAA are the

- only known chemicals with
- low Kd (adsorption to soil) and
- high RCF (adsorption to plant roots).
- = bioavailable and bioaccumulative
- and highly persistent!

Overall Summary (three cases)

i) **Heavy Metals**

Legal standards exist for both soil and vegetables.
In KH little transfer into garden plants, but risk of direct soil ingestion.

ii) **TCE trikloroetylen** is a frequent groundwater pollutant in DK

Legal standards for soil exist (5 mg/kg). There is little or **no risk** for uptake into fruits, such as apples.

iii) **Perfluoroalkyl acids PFAA**

Widely used persistent compounds. PFOA and PFOS no longer used, but others are. Their unique properties make them **suspect** for very high accumulation in leaves and fruits.

No legal standards (yet?), more studies welcome.

Any Questions?

Acknowledgements

to Andrea Gredelj for the PFAA data

to Bill Doucette for the TCE case

to my students Marlies Warming, Mette G. Hansen, Cindy M. Jespersen and Martin B. Jørgensen for the heavy metal data

to Sinh Nguyen for help in the lab

to Peter E. Holm, Jakob Magid, Thomas H. Hansen (KU) for cooperation.

Thank YOU for your attention!