Is octamethylcyclotetrasiloxane (D4) a Persistent Organic Pollutant?

Weighing the Evidence and Risk to Arctic Environments

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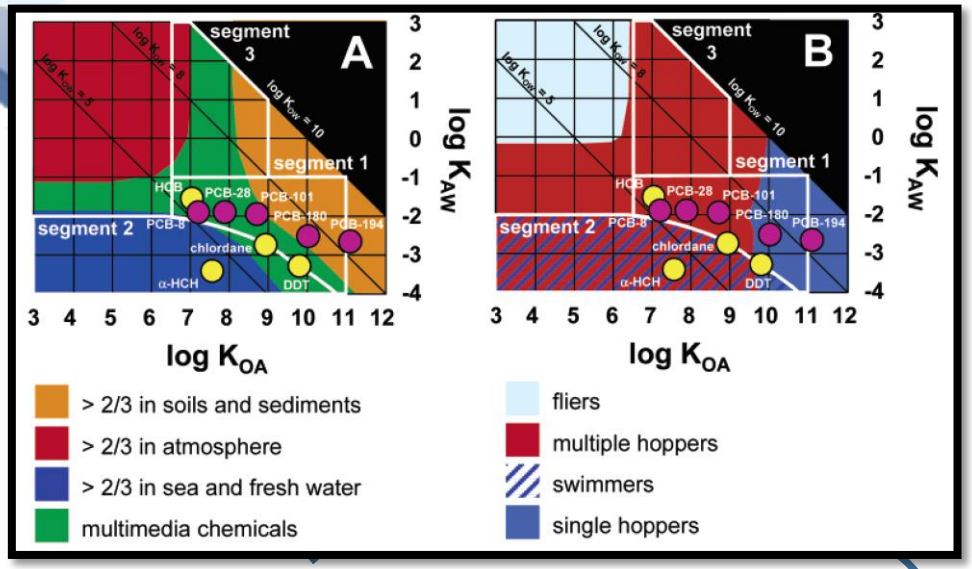
PBT criteria for identifying POPs

Stockholm Convention

- Persistence (P) – media based half-life ($T_{1/2}$)
  - Water: $T_{1/2}$ > 2 Mo
  - Soil/Sed: $T_{1/2}$ > 6 Mo
- Bioaccumlation (B)
  - BCF/BAF > 5000
  - Log K_{ow} > 5
- Toxicity (T)
- Long range transport potential (LRTP)
  - $T_{1/2}$ (air) > 2 days

Transfer efficiency (TE)

% TE = Rate of mass flux to receptor region x 100
Rate of emission in Source region



Source region

Receptor region

- Chemical partitioning properties (K_{aw}, K_{oa})
- Environmental properties of receptor region

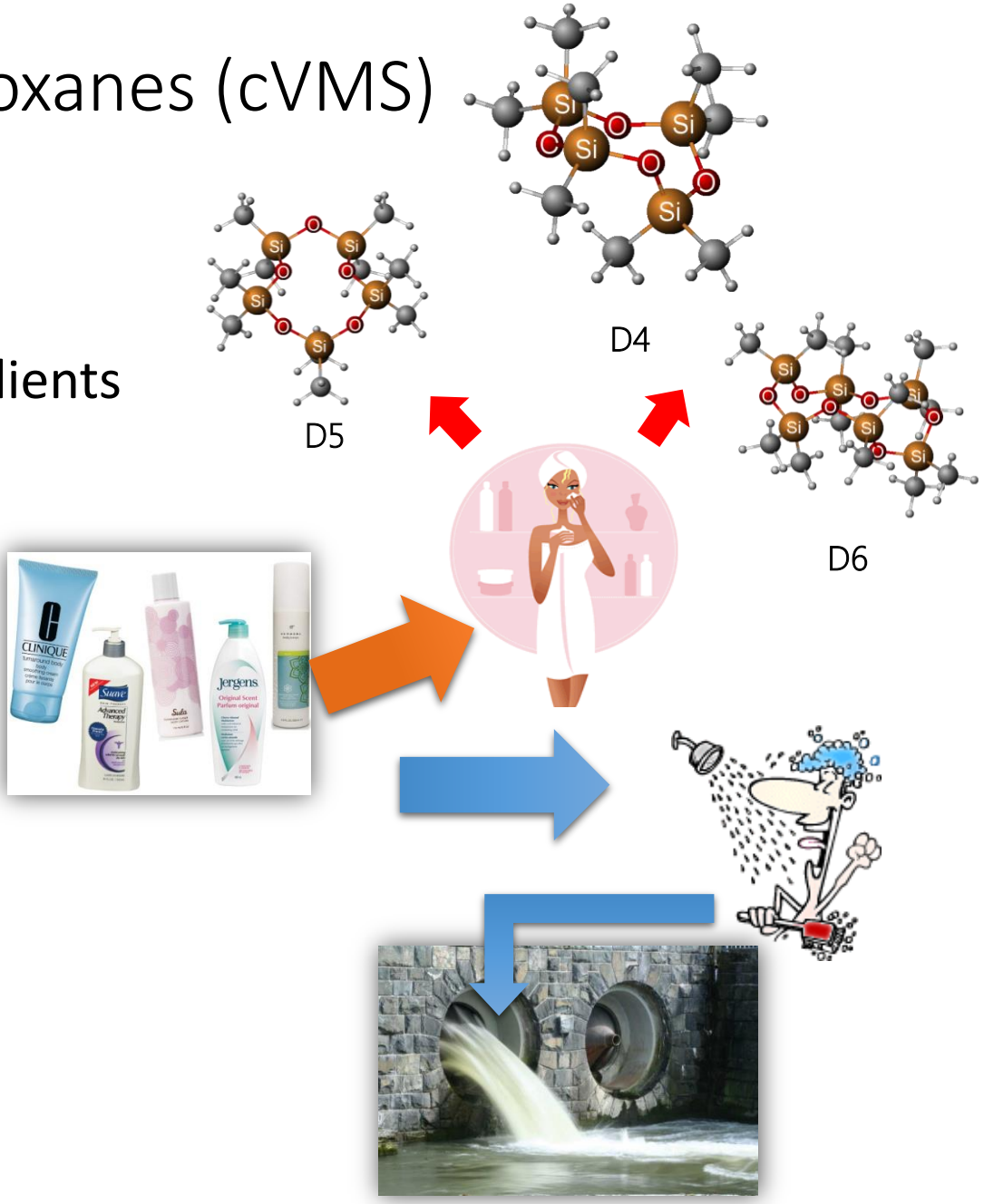
Macleod and Mackay. Environ. Pollut. 2004
Wania. Environ. Sci. Technol. 2003

Cyclic volatile methylsiloxanes (cVMS)

- Synthetic intermediates in polymer production
- Personal care product ingredients
- Volatile & hydrophobic
- 90% of emissions occur to atmosphere
  - *Log K_{aw}: 2.7 - 3.1*
  - *D4 $T_{1/2}$ ≈ 15 days*

- Present in aquatic environments
  - *Log K_{oc} : 4.2 – 6.0*
  - *Log K_{ow} : 7.0 – 9.1*

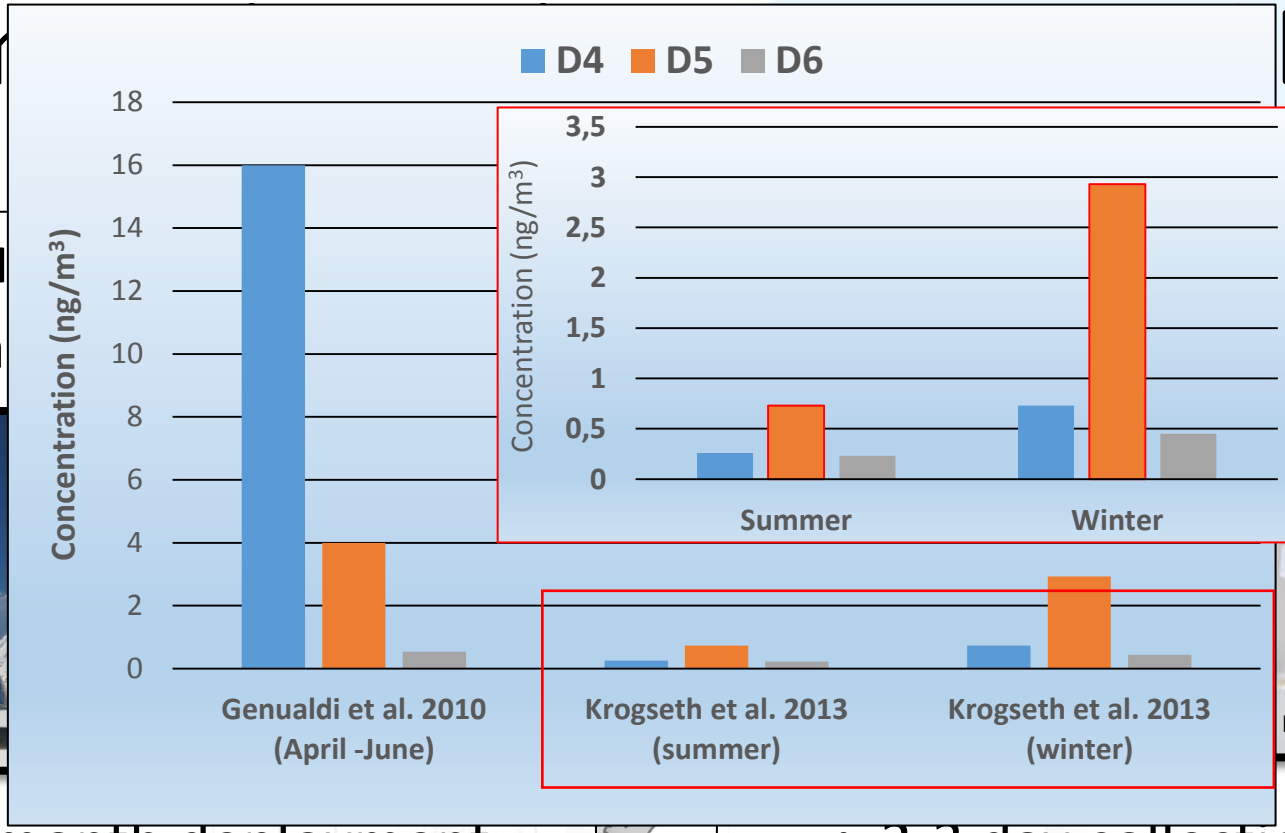
- D4 classified as PBT (ECHA 2015)
- **Evidence of LRT**
- **No evidence of deposition**



Wang et al. *Chemeosphere*, 2013, 93, 711-725.
European Chemicals Agency, Member state committee (MSC) opinion adopted on 22 April 2015.

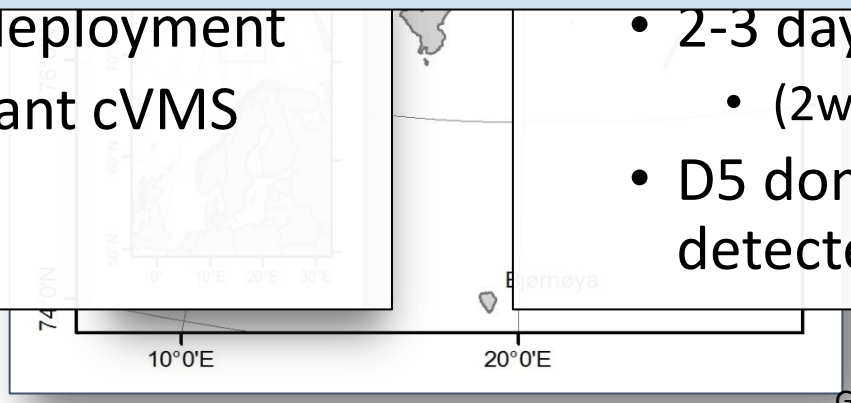
Rem D4

- Genu 013)
  - Pa



- 3 month deployment
- D4 dominant cVMS detected

- 2-3 day collection
  - (2weeks/summer/winter)
- D5 dominate cVMS detected



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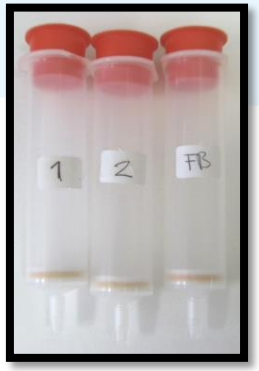
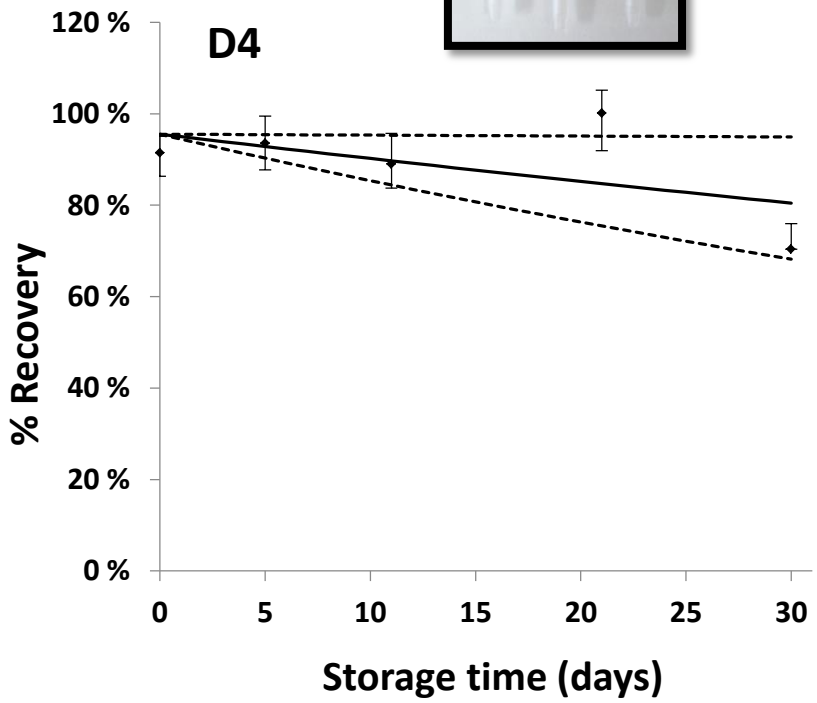
Genualdi et al. Environ. Sci. Technol. 2010
Krogseth et al. Environ. Sci. Technol. 2013a

Uncertainty surrounding D4

- Active sampling methodology
  - Degradation/formation on ENV+ sampling sorbent
  - Degradation of D5 to D4 during storage (-18°C)
  - All cVMS results storage corrected
- Passive sampling
  - sorbent impregnated polyurethane foam
  - Potential source of D4?

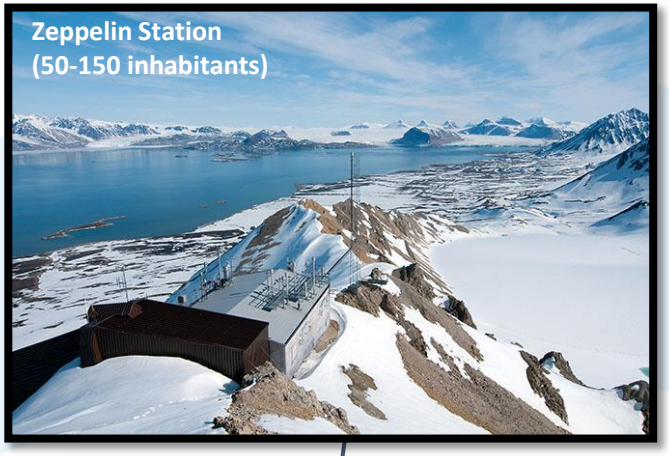


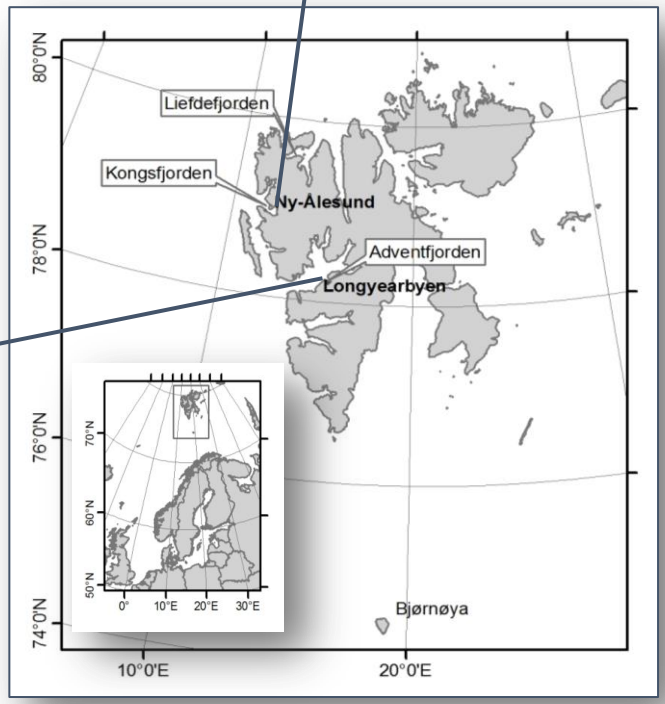


1. Krogseth *et al. Environ. Sci. Technol*. **2013b**.
2. Kirkegaard and McLachlan. Atmos. Environ. **2013.**

Influence of local sources

- Must differentiate between LRTP and local emission signatures
- Sampling location must be chosen carefully
  - Longyearbyen vs. Zeppelin Station
  - Minimize impact from local sources for LRT assessment





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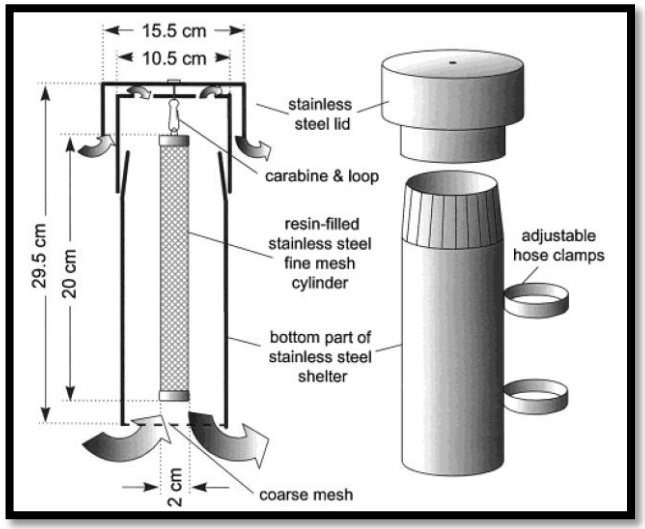
Remote atmospheric monitoring of cVMS using passive sampling

- XAD-2 sorbent based passive samplers
  - No use of polyurethane foam
  - No degradation of cVMS observed over 1 month storage time.
- Deployed on Svalbard for 2-3 months to assess/confirm cVMS LRT



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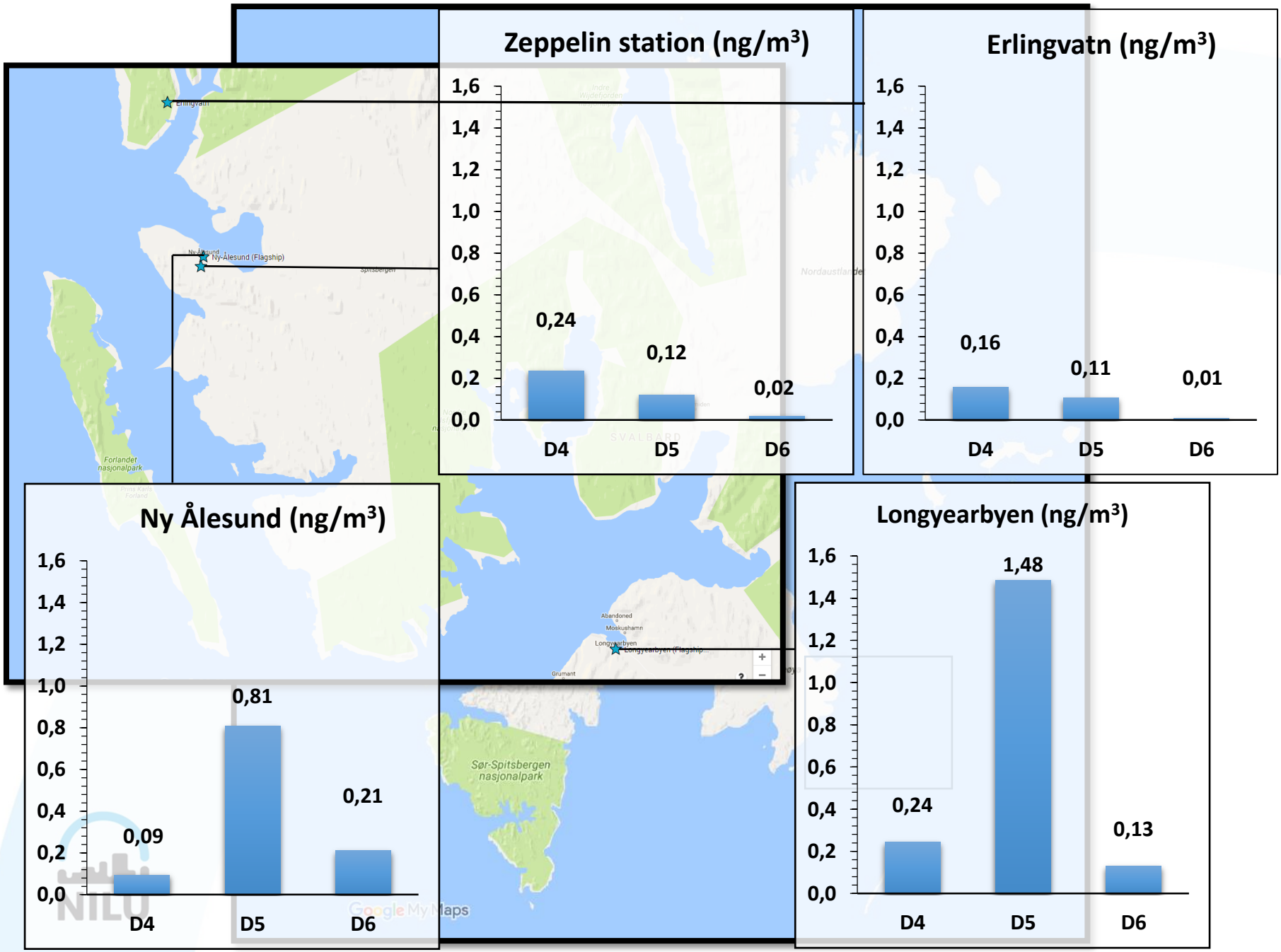
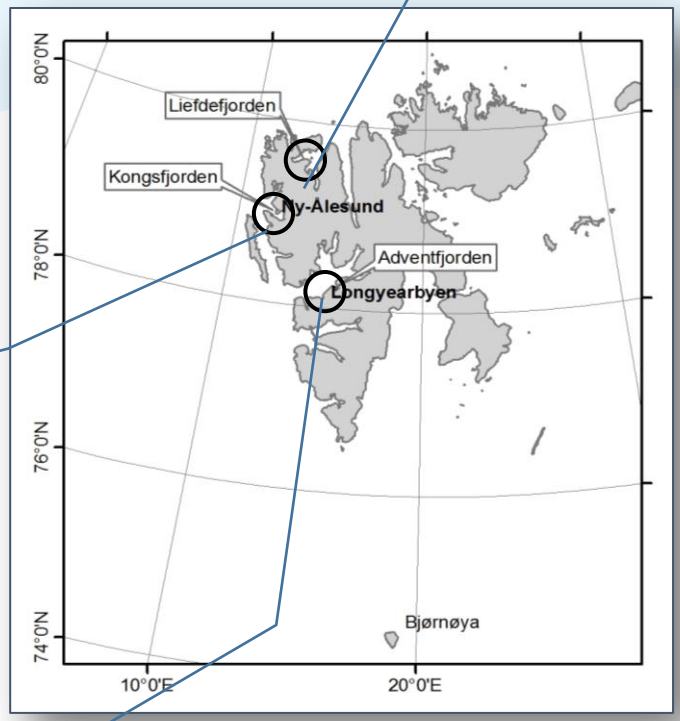
1. Krogseth *et al. Environ. Sci. Technol*. **2013b**. pp 4463 -4470


Zeppelin station (ng/m³)
1,6
1,4
1,2
1,0
0,8
0,6
0,4
0,2
0,0
0,24
0,12
0,02
D4
D5
D6
Erlingvatn (ng/m³)
1,6
1,4
1,2
1,0
0,8
0,6
0,4
0,2
0,0
0,16
0,11
0,01
D4
D5
D6
Ny Ålesund (ng/m³)
1,6
1,4
1,2
1,0
0,8
0,6
0,4
0,2
0,0
0,09
0,81
0,21
D4
D5
D6
Longyearbyen (ng/m³)
1,6
1,4
1,2
1,0
0,8
0,6
0,4
0,2
0,0
0,24
1,48
0,13
D4
D5
D6
Erlingvatn
Ny-Ålesund (Flagship)
Forlandet nasjonalpark
Sør-Spitsbergen nasjonalpark
Longyearbyen
Abandoned
Moskushamn
Grumant
Google My Maps

Deposition potential

- Models predict deposition of D4 will not occur in Arctic regions
- Confirmed by monitoring data
  - **Sediment** at remote locations

Liefdefjorden
No cVMS detected



Ny Ålesund
No cVMS detected

Longyearbyen
D5: 1-2 ng/g dw
(Local source)

1. Warner *et al. Environ. Sci. Technol*. **2010**.
2. Xu and Wania. Chemeosphere. 2013

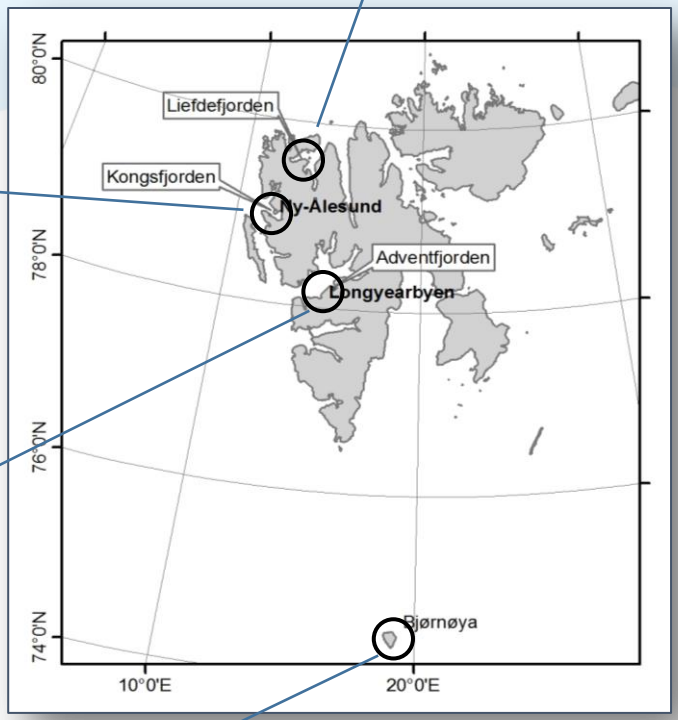
e risk

Ny Ålesund

Fish liver: **D4: not detected**
D5: 2 - 9 ng/g lw
D6: 1 - 16 ng/g lw
Kittiwake egg: no cVMS detected
Glauc.gull egg: **D4: 5.8 ng/g ww**
D5: 12 - 40 ng/g ww
D6: not detected

Erlingvatn (freshwater fish muscle)
No cVMS detected

Liefdefjorden (fish liver)
D4: not detected
D5: 2 ng/g lw*
D6: 1-2 ng/g lw*



Longyearbyen (fish liver)
D4: not detected
D5: 7 - 345 ng/g ww
D6: 2 - 5 ng/g ww

Bjørnøya (freshwater fish muscle)
No cVMS detected

- Concentrations heavily influenced by point sources
- D4 not present in stationary biota

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1. Warner *et al. Environ. Sci. Technol*. **2010**. pp 7705-7710
2. Lucia et al. NPI report, M-598. **2016**

Concluding remarks

- Physical/chemical properties help aid in identifying potential chemical risks to remote environments
- Current remote atmospheric data on D4 unreliable
- Improved passive sampler methodology confirms D4 LRTP potential
  - Distinguishing between local and LRTP signatures

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Concluding remarks

- D4 not present in deposition media (sediment and stationary biota)
  - Confirms model predictions
  - No risk of exposure via LRT
- Does LRT potential alone dictate exposure risk in remote environments ?
  - Must see the whole picture

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Acknowledgements

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Thank you for your attention