DTU Environment
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Monitoring of heavy metal subsurface contamination using trees

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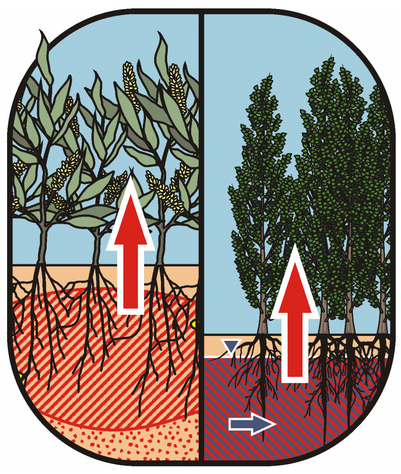
Why sampling trees?

Tree core sampling provides a new rapid, inexpensive and low-invasive alternative to investigate the extent and temporal development of subsurface contaminations (Trapp et al. 2008)

- trees root into groundwater
- trees transport water upwards
- wood adsorbs compounds
- each tree is a combination of well, pump & passive sampler



- root depth 3-8 m in average
- "Standard plant" transpires approx. 1 L/d (temperate climate zone)
- Wood is sampled with a drill, wood samples are analyzed with common methods
- Chemical residues in wood indicate sub-surface contamination

Tree core sampling was repeatedly and successfully applied to delineate subsurface plumes of chlorinated solvents (Larsen et al. 2008)

Study site

Former waste dumping site Møringa near Horten, Norway, forming an artificial half-island at the Oslofjord

- Deposition of waste oil, oil distillery waste, welding slag, blowing sand and building residues from around 1900 to 1993
- Originating from ship yards, oil recycling, ship and aircraft maintenance, and lead battery production
- Wastes were deposited by filling up a beach area from the land side, at later stages extending the waste deposit into the sea
- Depth of the waste deposit: approx. 3 m
- On the site, a wild-type pioneer vegetation consisting of grassland and trees (mainly willow, birch, cherry) developed

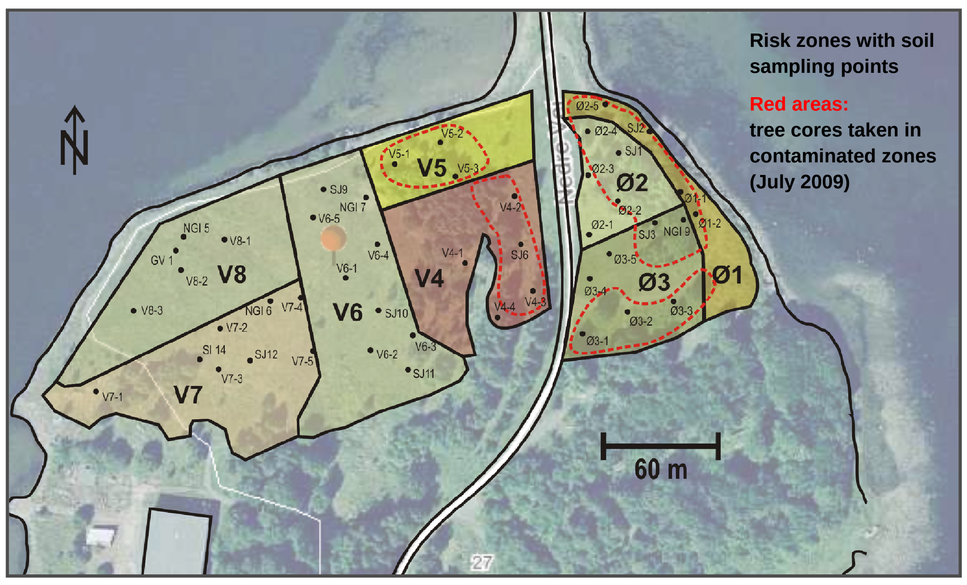
Objective

Objective: methodology test for finding heavy metal subsurface pollution

- sampling of different tree species in July 2009
- results obtained by ICP analyses were compared to element concentrations (As, Cd, Cr, Cu, Ni, Pb, Zn) in soil

Soil & tree core sampling at Møringa

- Intensive site investigation 1990-2005 revealed extensive contamination with various amounts of As, Cd, Cr, Cu, Ni, Pb and Zn
- 8 risk zones mapped, each with relatively homogeneous waste filling (Amundsen et al. 2005)



Correlation between tree cores and soil samples

1) all trees (mostly birch and willow; also cherry, aspen and ash):
   - Positive correlation, but not significant for any metal

2) only willow trees (*Salix caprea*):
   - high and significant correlation for arsenic, cadmium and chromium

Metal	Correlation
Arsenic As	0.422
Cadmium Cd	0.739
Chromium Cr	0.318
Copper Cu	-0.157
Nickel Ni	-0.172
Lead Pb	-0.479
Zinc Zn	-0.195

Table: Pearson product-moment correlation coefficients r

Negative correlation for Pb: probably due to contamination from traffic (higher in references)

- significant difference in the mean contents (t-test) in wood from the polluted site compared to wood from reference sites

Conclusions and outlook

- Preliminary results indicate that the methods works fine for arsenic, cadmium and chromium if willows are sampled
- Investigation will continue at the Møringa site and at Danish sites contaminated with heavy metals
- Goal: to obtain a rapid but reliable method for screening and monitoring of contaminated sites for subsurface pollution with heavy metals & other elements

Literature

Amundsen CE, French H, Aasen R, Nordal O. 2005. Supplementary investigations at Møringa waste site, Horten. Risk assessment and remedial action plans (in Norwegian). Jordforsk-report. 19/05. Bioforsk, 1432 Aas, Norway.

Larsen M, Burken J, Macháčková J, Karlson UG, Trapp S. 2008. Using tree core samples to monitor natural attenuation and plume distribution after a PCE spill. Environ. Sci. Technol. 42, 1711–1717.

Trapp S, Larsen M, Legind CN, Burken J, Macháčková J, Gosewinkel Karlson U. 2008. A guide to vegetation sampling for screening of subsurface pollution. Available at http://homepage.env.dtu.dk/stt/GuidetoVegetationSampling.pdf

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