The Feasibility of Tree Coring as a Screening Tool for Selected Contaminants in the Subsurface - DTU Orbit (16/12/2018)

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Chemical release resulting from inadequate care in the handling and storage of compounds has ultimately led to a large number of contaminated sites worldwide. Frequently found contaminants in the terrestrial environment include BTEX (benzene, toluene, ethylbenzene, and xylene), heavy metals, PAHs (polycyclic aromatic hydrocarbons) and chlorinated solvents. The large number of contaminated sites has created a need for effective and reliable site investigations. In this PhD project the feasibility of tree coring as a screening tool for selected contaminants in the subsurface has been investigated to obtain more efficient site investigations. Trees have a natural ability to take up water and nutrients from the subsurface; consequently, contaminants can also enter the roots and be translocated to plant parts above ground where they will be absorbed, degraded or phytovolatilized depending on their physico-chemical properties. A small sample of the wood (a tree core) can be collected and analyzed to give information on potential subsurface contamination. To date the focus of tree coring has mainly been on the use as a screening tool for chlorinated solvents including perchloroethylene (PCE) and trichloroethylene (TCE), where the method has been applied with success. The results also showed that the measurements will be affected by various factors such as soil properties, climate conditions, sampling procedure, the tree species and especially the contaminants of interest.

The purpose of this PhD project is comprised of two primary objectives: (1) to investigate the feasibility of tree coring of different tree species as a screening tool for heavy metals, BTEX and PAHs in the subsurface and (2) to investigate under which conditions and for which purposes tree coring is a viable substitute for established site screening methods e.g. soil gas sampling. The first objective was achieved through tree core sampling campaigns from different tree species (e.g. willow, poplar, birch, cherry, and ash) at sites contaminated with heavy metals, BTEX or chlorinated solvents. The measured wood concentrations were compared to concentrations in soil, groundwater or soil gas. In addition, a laboratory study has been conducted to investigate the plant uptake of PAH from different soils. The second objective was accomplished by comparing wood concentrations attained through tree coring to measurements of soil gas, soil and/or groundwater attained through established site characterization methods.

The site investigations showed that the use of tree coring as a screening tool for heavy metals and BTEX in the subsurface is more complex than for chlorinated solvents. Heavy metals were expected to be good candidates for tree coring due to natural uptake mechanisms of essential heavy metals, but the use of tree coring to detect elevated heavy metal concentrations in soil is challenged by the presence of background concentrations. Therefore, a statistical comparison of the wood concentrations measured in trees grown at a potentially contaminated site and trees from a nearby non-contaminated site (reference trees) is necessary. This approach has demonstrated significantly elevated concentrations of zinc (Zn), copper (Cu), cadmium (Cd) and nickel (Ni) in trees grown at highly contaminated sites, while less or no significant elevated concentrations were found in trees from less contaminated sites. In addition, non-linear relationships were found between concentrations in wood and soil.

BTEX have similar physico-chemical properties as chlorinated solvents, so was expected that BTEX also would be good candidates for tree coring. However, the application of tree coring to locate BTEX-contaminated areas can be difficult as natural attenuation of the compounds (e.g. biodegradation and volatilization) may result in relatively low concentrations in the wood. Although difficult, investigations have shown that some BTEX contaminated areas can be detected by tree coring and that the concentrations of BTEX in wood can be correlated to those in soil, groundwater or soil gas. Precautions implemented to prevent cross-contamination have also shown to be important because it can otherwise lead to false positives. Among the sampled tree species, willows and poplars were the most suitable species for tree coring, since they were able to take up heavy metals and BTEX in highest concentrations. The laboratory study of PAH plant uptake from soil showed that the plant concentrations were not controlled by total soil concentrations or the bioavailable fraction in the soil. Concentrations measured in plant tissue above ground were more affected by deposition from air.

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The comparison of tree coring and soil gas sampling for application as screening tools for chlorinated solvents showed that the two methods are complementary, which is why the choice of method to be used should be based on the specific purpose of the site investigation and the specific site conditions.

In general, tree coring is a very rapid and low-invasive screening method, which provides an economic advantage to current methods. The low costs associated with tree coring allow for a high sampling density. This, together with a relatively large soil volume represented by a tree core, has shown to reduce the risk of overlooking contaminated areas and is a valuable method for the identification of previously unknown source areas within a short time period.

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