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Comparison of soil-monolith extraction techniques

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In the international literature the term „lysimeter“ is used for different objectives, e.g. suction cups, fluxmeters, etc. According to our understanding it belongs to the direct methods to measure water and solute fluxes in soil. Depending on the scientific task the shape and dimensions of the lysimeter as well as the type of filling (disturbed or undisturbed) and the specific instrumentation can be different. In any case where water dynamics or solute transport in natural soil is considered, lysimeters should be filled with 'undisturbed' monoliths which are large enough to contain the small scale heterogeneity of a site since flow and transport is highly sensitive to soil structure. Furthermore, lysimeters with vegetation should represent the natural crop inventory and the maximum root penetration depth should be taken into account. The aim of this contribution is to give an overview about different methods for obtaining undisturbed soil monoliths, in particular about i) techniques for the vertical and ii) for the horizontal extraction and iii) to evaluate the most frequently used procedures based on X-ray tomography images.

Minimal disturbance of the soil monolith during extraction and subsequence filling of the lysimeter vessel is of critical importance for establishing flow and transport conditions corresponding approximately to natural field conditions. In the past, several methods were used to extract and fill lysimeter vessels vertically - including hand digging, employing sets of trihedral scaffold with lifting blocks and ballast, or using heavy duty excavators, which could shear and cut large blocks of soil. More recently, technologies have been developed to extract cylindrical soil monoliths by using ramming equipment or screw presses. One of the great disadvantages of the mentioned methods is the compaction or settling of soil that occurs during the "hammering" or "pressing". For this reason a new technology was developed, which cuts the outline of the soil monolith employing a rotary cutting system. This procedure should avoid structural damages and substantially reduces the necessary technical expenditure during monolith extraction. This "cutting" technology has been used successfully for different soil types (from gravel to sand to clay including contaminated sites) and for different lysimeter sizes (surface area 0.1-2 m2 and depths of 0.5-3.0 m).

There is evidence in literature that lateral water and solute fluxes cannot – or only insufficient – be examined with conventional lysimeters. Lateral fluxes are of particular importance in groundwater dominated systems, as peat soils (fens or Histosols). To investigate lateral transport processes a box-shaped stainless steel lysimeter vessel (4 m long, 1 m width and 1.5 m depth) was constructed. The most challenging task of the extraction procedure was the horizontal sliding of the lysimeter vessel through the natural peat soil. At the front of the vessel a cutting tool assists in carving the soil monolith out of the peat, both vertically and at the base of the vessel. The yet unfilled vessel was inserted at the extraction site into an already prepared starting pit and aligned to a guiding system (guide tracks) adjustable in three axes. Serrated knife bars were used for cutting. A hydraulic plunger was used to support the cutting procedure. The whole horizontal extraction technology will be described and demonstrated.

For the evaluation of the different extraction technologies with respect to the potential disturbance of soil structure we applied the different techniques for the same soil type (Eutric Fluvisol). At natural site conditions soil monoliths with the same size have been extracted with the "hammering", the "pressing" and the "cutting" technology. The soil structure close to the vessel wall was recorded using X-ray tomography at a resolution of some 0.1 mm. The results will be demonstrated and discussed.