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Investigations on the suitability of suction cups for sampling of soil water with organic contaminants

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Suction cups enable in-situ sampling of soil water e.g. within the framework of a leachate forecast on contaminated sites directly at the place of assessment in order to determine the amount of mobile contaminants. Interactions of soil water ingredients with the suction cup materials should be as small as possible to avoid changes of soil solution during the sampling process.

Suction cups have been applied successfully for a long time in agriculture and forestry in particular for the investigation of inorganic compounds in soil water. A comprehensive literature review indicated that no sufficient experience is available for contaminated sites assessment so far, in particular in connection with organic pollutants.

In order to investigate the suitability of common suction cups for this application laboratory experiments were performed on PAH and TPH contaminants. A test solution (model or real) was pumped from a storage container through the suction cups into a collecting bottle.

The initial recovery rate of the test solution was determined. The percolated solutions were measured after the tests and the suction cups were extracted to determine the retained amount of contaminants by the suction cup itself. The test duration depended on the flow rate of various suction cup materials and the amount of solution needed for the analysis. The investigations were carried out using common suction cups of different materials such as $Al_2O_3$and SiC ceramics, PTFE/quartz, boron-silicate glass and stainless steel.

The maximum pore size indicated by the producers of suction cups is usually calculated from the bubble point which represents only a guesstimate. Substantial differences were found in the flow rates of suction cups (even for suction cups of the same type), which are obviously not only related to the pore size but also to the pore shape and surface features. For example the pore size of the stainless steel suction cups is larger those of ceramic ones. Nevertheless, ceramic cups provide a higher flow rate. Therefore material investigations such as surface area and pore size distribution measurements as well as scanning electron microscopy were conducted. Due to the high complexity of the relations between material and pore characteristics the results and figures of these material investigations are very helpful to clarify the causes for the different behaviour of various suction cups.

Substantial losses of TPHs were found for all investigated materials using the model solution. PAHs, especially those with higher molecular sizes (i.e. greater number of rings) also showed high losses. A somewhat better view was obtained from experiments using real test solutions (groundwater from a TPH contaminated site and an eluate from a soil contaminated with PAH).

It was proved that stainless steel suction cups have a relatively low specific surface area of 0.22 m^2/g and therefore adsorb smaller amounts of contaminants, but are prone to plugging due to the non-uniform pore radius distribution from 2 to 50 μm. It was also found that common ceramic suction cups with a higher specific surface area of 4.21m^2/g and a uniform pore size distribution (about 0.2 μm) are only suitable to a limited extent for investigations of soil water with TPHs and PAHs due to their extensive adsorption capability. Despite their advantageous pore features and additional coating with quartz PTFE suction cups maintain a high hydrophobic property which causes a very low flow rate and therefore adverse long test durations for tests on organic contaminants.

Ultimately, none of the suction cups investigated exhibits all desired characteristics and offers optimum suitability for soil water investigations in connection with TPHs and PAHs. Depending on the contaminant to be tested, a suitable suction cup material has to be carefully pre-selected for each site assessment procedure.