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Determination of degradation rates of organic substances in the unsaturated soil zone depending on the grain size fractions of various soil types

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Rate and extent of the biological degradation of organic substances during transport through the unsaturated soil zone is decisively influenced by the chemical and physical properties of the pollutants such as water solubility, toxicity and molecular structure. Furthermore microbial degradation processes are also influenced by soil-specific properties. An important parameter is the soil grain size distribution on which the pore volume and the pore size depends. Changes lead to changes in air and water circulation as well as preferred flow paths. Transport capacity of water inclusive nutrients is lower in existing bad-drainable fine pores in soils with small grain size fractions than in well-drainable coarse pores in a soil with bigger grain size fractions. Because fine pores are saturated with water for a longer time than the coarse pores and oxygen diffusion in water is ten thousand times slower than in air, oxygen is replenished much slower in soils with small grain size fractions. As a result life and growth conditions of the microorganisms are negatively affected. This leads to less biological activity, restricted degradation/mineralization of pollutants or altered microbial processes.

The aim of conducted laboratory column experiments was to study the correlation between the grain size fractions respectively pore sizes, the oxygen content and the biodegradation rate of infiltrated organic substances. Therefore two columns (active + sterile control) were filled with different grain size fractions (0,063-0,125 mm, 0,2-0,63 mm and 1-2 mm) of soils. The sterile soil was inoculated with a defined amount of a special bacteria culture (sphingobium yanoikuae). A solution with organic substances glucose, oxalic acid, sinaphylic alcohol and nutrients was infiltrated from the top in intervals. The degradation of organic substances was controlled by the measurement of dissolved organic carbon in the in- and outflow of the column. The control of different pore volumes respectively pore sizes in the soil samples occurred by air pycnometer measurement and determination of soil moisture characteristic by evaporation method according to Wind/Schindler.

The present study results can be useful to find a correlation between various soil types with different grain size distributions and the suitability of these soils for example for the infiltration of treated wastewater in the context of managed aquifer recharge (MAR) measures.