Experimentally designed Partitioning Interwell Tracer Test (PITT) for assessing subsurface NAPL contamination

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Partitioning Interwell Tracer Test (PITT) have been used as the method to estimate the volume of Non Aqueous Phase Liquid (NAPL) contaminating subsurface zone. This method applies two kinds of tracers, one is the partitioning tracer which penetrates into NAPL nuggets contaminating the subsurface zones, the other is the non-partitioning tracer which doesn't penetrate into it. By using these two kinds of tracers, PITT is potentially capable of estimating the quantity of NAPL. Since this chromatographic separation of the tracers is based on the partition law, it is most important to determine the partitioning coefficients of the tracers. However, the accuracies of the PITT would be influenced not only by the partitioning coefficients, but also by the conditions of NAPL contamination and tracer velocities. The effects of these factors on the accuracies of PITT have not been confirmed sufficiently up to now, probably due to the lack of the basic research compared with the practical requirement. The objectives of this study are to show the effects of 1) the NAPL nugget sizes, and 2) the tracer velocity on PITT. And 3) the accuracy and application of PITT is studied.

We made two kinds of laboratory column experiments for above purposes. Three kinds of NAPL nugget sizes were used to find the effects of the NAPL nugget sizes and five types of tracer fluxes were used to understand the effects of the tracer velocities on PITT. To understand the effects of the NAPL nugget sizes, we simulated the coagulate type NAPL contamination that exist through the continuous soil pores. This coagulate type NAPL contamination was mimicked by NAPL nugget. In this study, we used the porous medium made of kaolinite that absorbed Trichroloethylene (TCE) as NAPL nugget. To change the NAPL nugget sizes, we used the NAPL nuggets which had the different diameters, less than 2 mm, from 2 to 5 mm, and from 5 to 15 mm. And these NAPL nuggets were filled into columns with Toyoura-sand. In contrast, to understand the effects of the tracer velocities, we simulated the isolate type NAPL contamination that retain in soil pores as small blob. To make this type contamination, we inject TCE liquid from the top of the column, and after that, put a lot of water through the column. Isopropyl alcohol (IPA) was used as a non-partitioning tracer, and 4-methyl-2-pentanol (4M2P) and 5-methyl-2-hexanol (5M2H) were used as the partitioning tracers. The water-TCE partitioning coefficient of 5M2H is larger than 4M2P. We used a column made of PTFE, the inner diameter is 2 cm, the length is 13 cm. The lower end of this column was connected to the fraction collector, and sample was collected at regular time intervals and analyzed by GC-FID. And we simulated the saturated zone in this column. The flow volume was controlled by peristaltic pump.

In the experiments of changing the NAPL nuggets sizes, the separation of Break Through Curves (BTCs) was larger when the NAPL nuggets sizes were smaller. The tailings were longer when the NAPL nuggets sizes were larger. It is practically important that the degree of separations of the BTC-peaks and the lengths of the tailing are sensitive to the sizes of NAPL nuggets embedded in the subsurface zones. In the experiments of changing the tracer velocities, when tracer flux was smaller than 0.020 cm min^{-1}, the peaks of the BTCs of the partitioning and non-partitioning tracers were separated, and when the flux was larger than 0.065 cm min^{-1}, , the peaks of them were not separated. And the accuracy of PITT is better when the tracer velocity is low than when the velocity is high. And the accuracy of PITT is extreme low when the NAPL exists as coagulate type in comparison with existing as blob. We should use appropriate tracers and tracer velocity when apply PITT in the field.