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Geotechnical centrifuge modelling of transverse hydrodynamic dispersion in uniform unsaturated material

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Physical modelling of pollutant transport is limited to unpractical field and laboratory experiments [1]. The use of a geotechnical centrifuge offers an alternative physical modelling technique to the currently preferred numerical methods but there is limited research that evaluates the effect an increased acceleration level has on transverse hydrodynamic dispersion. To investigate this, a geotechnical centrifuge model was developed where six experiments with uniform fine-grained sand and two experiments with uniform coarse-grained sand were conducted at multiple acceleration levels.

Results indicate that the movement of the hydrodynamic dispersion plume occurred as four scenarios dependent on the gravitational acceleration level and grain size distribution, which ultimately resulted in four distinct final shapes. Increasing the gravitational acceleration resulted in reduced hydrodynamic dispersion readings, with possible threshold dispersion distance readings ranging between 50 - 70 mm from 20g onwards in fine-grained sand. In addition to this, the scaled dimensions using scaling factors between 1:$N^{0.75}$ and 1:$N^{0.9}$ provide data with minimal scatter and exhibit a strong correlation with a polynomial and logarithmic relationships. Extrapolation of the data using logarithmic relationship provided plume widths ranging between 2.4 m - 4.0 m at 30 m prototype depth and results in a plume width to plume depth ratio of approximately 1/10, which is a common ratio assumed for the two coefficients in groundwater modelling [2].

The good accordance of scaled dispersion plume model dimensions and numerical methods supports the geotechnical centrifuge as a viable experimental tool for physical modelling of dispersion plume migration in unsaturated media.

References:

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