FLUORESCENT MICROSPHERES:
Developments in Colloid & Contaminant Tracing

H. A. Sinclair, Department of Geography, University of Sheffield

Introduction

Fluorescent microspheres, available in a wide range of sizes and colours, can be an effective suite of tracers for studying the movement of colloids and associated contaminants through soils and other porous material. Although these tracers can be detected directly in aqueous samples by fluorescence spectroscopy, particulate matter within the sample can cause considerable interference. By employing an analytical method similar to that used in biomedical research, interference can be reduced and sensitivity increased by dissolving the polystyrene matrix of the microspheres releasing all of the dye within the beads into solution.

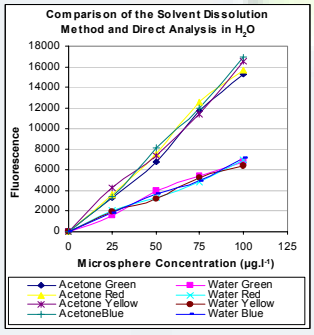
The Solvent Dissolution Method (SDM)

- Filter aqueous sample to trap microspheres*
- Pass acetone through filter to dissolve microspheres and elute dye.
- Fluorimetric analysis of acetone/dye solution gives microsphere concentration.

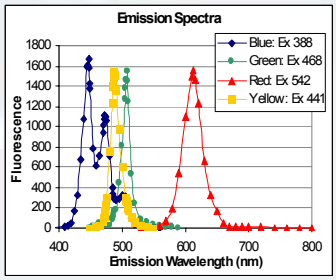
Method Comparison

Preliminary trials comparing microsphere detection by direct analysis in aqueous suspension with the SDM highlighted several advantages to using the SDM.

- Reduction in linterference
- Increased fluorescence
- Lower detection limit (~0.01µg.l^{-1} in acetone, 1µg.l^{-1} in water)
- Pre-concentration of dilute samples
- Microsphere detection in solid samples[1]
- Simultaneous detection of multiple particle sizes.



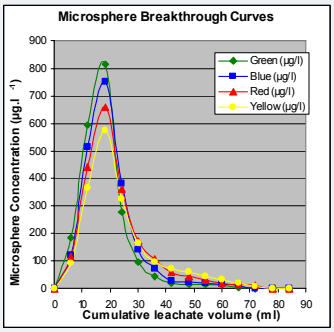
Comparison of measured fluorescence by direct analysis in aqueous suspension and by the SDM.



Emission spectra for four different colours/sizes of microsphere in a single sample.

[1] For microsphere detection in solid samples, the whole sample is placed in acetone to extract the fluorescent dye, and the mixture is filtered to remove particulates prior to fluorescent analysis.

Tracer Breakthrough Analysis

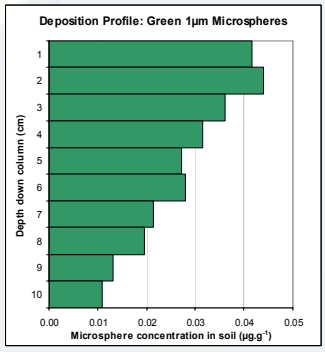


Breakthrough curves for four sizes of microsphere from a small, soil packed column.

The characteristic shape of the tracer breakthrough curves, with pronounced tailing after an initial strong peak, suggests that deposition and remobilisation processes may be taking place within the porous matrix of the columns.

Colloid Deposition

To further investigate colloid deposition during the transport process, the soil is carefully extruded from the column and cut into sections of equal depth, before using the solvent dissolution method measure the microsphere concentrations present in each.



Deposition profile for 1µm, green fluorescing microspheres in a packed soil column.

Microsphere deposition profiles show that deposition occurs throughout the full depth of the column, while greater concentrations near the surface may suggest that physical filtration processes as the tracers enter the soil play an important role.

Further Work

- Investigate colloid deposition patterns further.
- Compare microsphere transport characteristics with those of natural colloids.
- Explore use of microspheres, and SDM for larger scale tracing experiments.

Conclusion

Fluorescent microspheres, in conjunction with the SDM, are an interesting, versatile alternative to other particulate tracers, potentially offering insight into the transport and deposition characteristics of colloidal and particulate material within porous media.

Further information on this research can be obtained from: Hazel Sinclair, Department of Geography, University of Sheffield, Winter Street, Sheffield, S10 2TN, U.K.
Tel: 0114 222 27973 Email: h.sinclair@sheffield.ac.uk