

How in situ heterogeneity affects the uncertainty of measurements of contaminant concentration

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In order to characterise and manage environmental contamination it is becoming evident that it is not enough just to measure the concentration of the contaminant in whatever medium it arises, but also to estimate the uncertainty of this measurement value. Increasingly it is recognised that this uncertainty should include the contribution from the sampling, as well as the analytical processes[1]. Previous studies across a number of contaminated land sites have found widely different values of the uncertainty from sampling which range from 25% to 83% of the estimated concentration value for metals and organic contaminants. The variability of these uncertainty values has been attributed largely to differing degrees of heterogeneity in the spatial (or temporal) distribution of the contaminant *in situ*[2]. Experimental designs have been described for quantifying this in situ heterogeneity of contaminants, and how this varies as a function of the scale (from μm to 100m) [3,4]. Results will be reported here from application of these designs at a number of contrasting sites, in order to review how *in situ* heterogeneity varies between different contaminants and between sites for

the same contaminant. This will be used to assess the implications of this heterogeneity for the uncertainty of measurements, and for improving sampling protocols. For example is it possible to quantify the potential benefits of using composite samples within a sampling protocol, and to decide the optimal number and separation of increments within each composite sample, to address any stated objective.

The objectives of this paper are therefore:

- a) Review the definitions of *in situ* heterogeneity (spatial and temporal) and also the methods by which it can be quantified
- b) Report on studies exploring how heterogeneity causes uncertainty in measurements, via both the design and the implementation of the sampling protocol
- c) Consider how choice of sampling protocol can be used to reduce the effect of heterogeneity on uncertainty of measurements

References

- [1] Ramsey M.H., and Ellison S. L. R.,(eds.) (2007) Eurachem/EUROLAB/ CITAC/Nordtest/ AMC Guide: Measurement uncertainty arising from sampling: a guide to methods and approaches Eurachem
- [2] Ramsey M.H. and Boon K.A. (2010) New Approach to Geochemical Measurement: Estimation of measurement uncertainty from sampling, rather than an assumption of representative sampling. *Geostan. & Geanal. Research*, 34, 293-304.
- [3] Taylor P.D., Ramsey M.H. and Potts, P.J. (2005) Spatial contaminant heterogeneity: quantification with scale of measurement at contrasting sites. *J.Env. Monit.*7,1364 – 1370
- [4] Thomas J.Y., Ramsey M.H., John E.A, Barnes R. (2008) Quantification of in situ heterogeneity of contaminants in soil: a fundamental prerequisite to understanding processes controlling plant uptake. *Proceedings of ConSoil 2008 (10th International UFZ-Deltares/TNO Conference on Soil-Water Systems), Milan, Italy, 3-6 June 2008 (ISBN: 978-3-00-024598-5). Theme C, 101-106*

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