Dipole tracer tests to examine flow and transport between wells

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Introduction

In many older landfills in the UK, significant depths of saturated waste exist (and are permitted) in sites benefiting from natural containment created by surrounding geology with low permeability. In order to accelerate solute flushing in these sites, the introduction of water and removal of leachate between vertical wells is a practical option. The basic hydraulic unit for such systems is a simple well-pair, whereby one well injects fluid and a second abstracts at the same rate. Such a pair is often called a dipole or a doublet. It is useful to understand flow and solute movement in this basic unit, which can thereafter be used to design more elaborate field-scale systems.

In this study, the hydraulic and contaminant transport properties of dipoles were examined at varying scales in a landfill by running dipole tracer tests using Rhodamine WT dye.

Methodology

The tests were carried out at a purpose-built research site on a restored landfill with a waste depth of ~25 m and a saturated depth of ~15 m. Four new fully screened wells and two observation piezometers were installed in line with an existing leachate extraction well (insert, Figure 1). Hydraulic and tracer tests have been carried out at the test site, including echo tests discussed by Rees-White *et al* (2014).

Leachate was pumped from an abstraction well at a constant rate of 2 m^3/hour and pumped directly back into the landfill via an injection well, forming a recirculation loop. When pressures had equilibrated, a tracer was added to the recirculating leachate. The first test was carried out with a well spacing of 10 m and the second at a well spacing of 20 m, each using the dye tracer Rhodamine WT (RWT). RWT tracer was monitored in the recirculation line using a fluorometer (Cyclops 7, Turner Designs), and samples collected from observation wells measured in the laboratory using a Cary Eclipse Spectrophotometer.

Results and Analysis

Figure 1, shows the tracer concentration normalised by the input concentration (C/C_0) measured since injection started for each test. First arrival in the abstraction well is rapid; 4.1 hours and 17.8 hours for Tests 1 and 2 respectively. Table 1 gives the first arrival times of tracer in each of

the monitored observation wells. Obs1 is a deep piezometer screened over 1m at the base of the landfill. Obs2, is screened within the upper 1 m of the saturated zone. No tracer was detected in Obs1 in either of the tests. A range of times for tracer breakthrough is given in each case, as arrival could have occurred between monitoring periods.

Modelling of the tracer data will be used to test our conceptual understanding of horizontal flow and transport at the field scale. Ultimately, simulations will be used to estimate a number of useful transport parameters, not least dual-porosity parameters which have been used successfully under different field conditions and in the laboratory. Experience with RWT, however, has highlighted the difficulties of using dyes as a quantitative tracer in waste due to storage, calibration and repeatability.

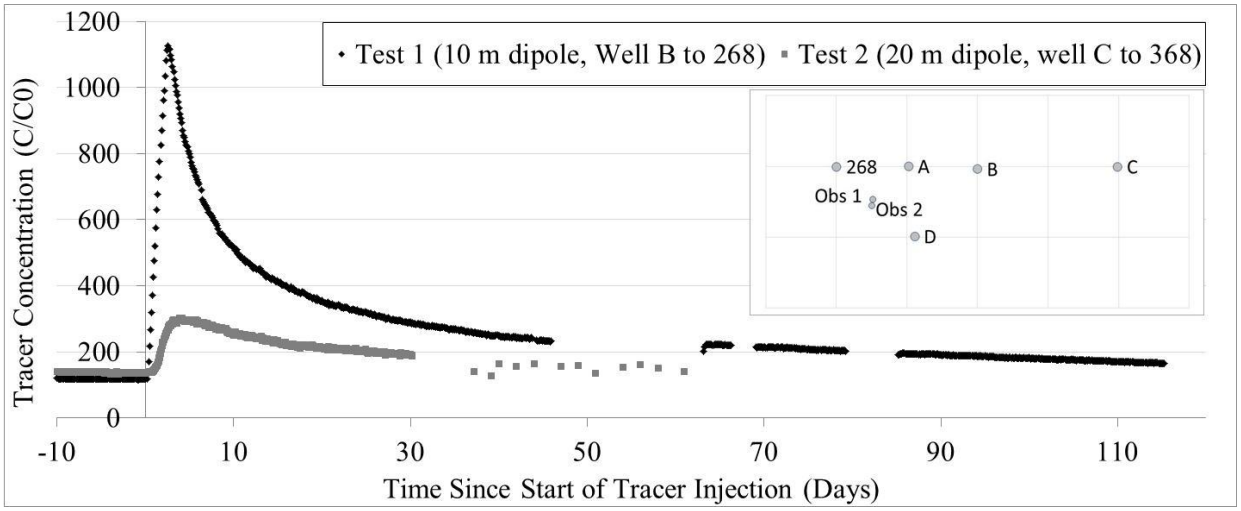

Figure 1. Normalised tracer concentration (C/C_0) over time. Well arrangement in insert.

Table 1. First Arrival (tracer breakthrough) times.

	Test 1 (10 m dipole)		Test 2 (20 m dipole)	
Well No.	**Distance from Inj. well (m)**	**First arrival (Hours)**	**Distance from Inj. well (m)**	**First arrival (Hours)**
268	10.0	4.1	19.9	17.8
A	4.9	00.0 – 3.2	14.8	6.0 – 22.3
B	0.0	Inj. well in Test 1	9.9	4.0 – 6.0
C	9.9	7.2 – 24.6	0.0	Inj. well in Test 2
D	6.5	7.5 – 24.6	15.2	47.5 – 50.5
Obs1	7.7	No tracer detected	17.5	No tracer detected
Obs2	7.9	3.7 – 7.4	17.6	22.3 – 25.0

References

Rees-White, T., Woodman, N. D. & Beaven, R. P. (2014) Evaluating echo tests as a contaminant transport characterisation tool, Intercontinental Landfill Research Symposium, Crystal River Florida