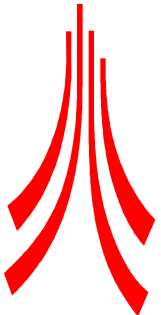


# The measurement of $^{99}\text{Tc}$ in natural waters using Diffusive Gradients in Thin Films (DGT) and TEVA resin.

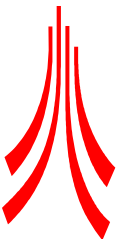
Jackie Pates and Hao Zhang

French et al. (2005) *Analytical Chemistry* 77: 135-139



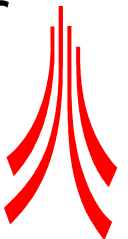
# Introduction

- Technetium-99:
  - long-lived,  $t_{1/2} = 211000$  years
  - beta emitter,  $E_{\max} = 294$  keV
- Environmental significance:
  - 1994-2004 Sellafield discharges to the Irish Sea
  - Groundwater contamination at nuclear sites, e.g. Sellafield, Hanford

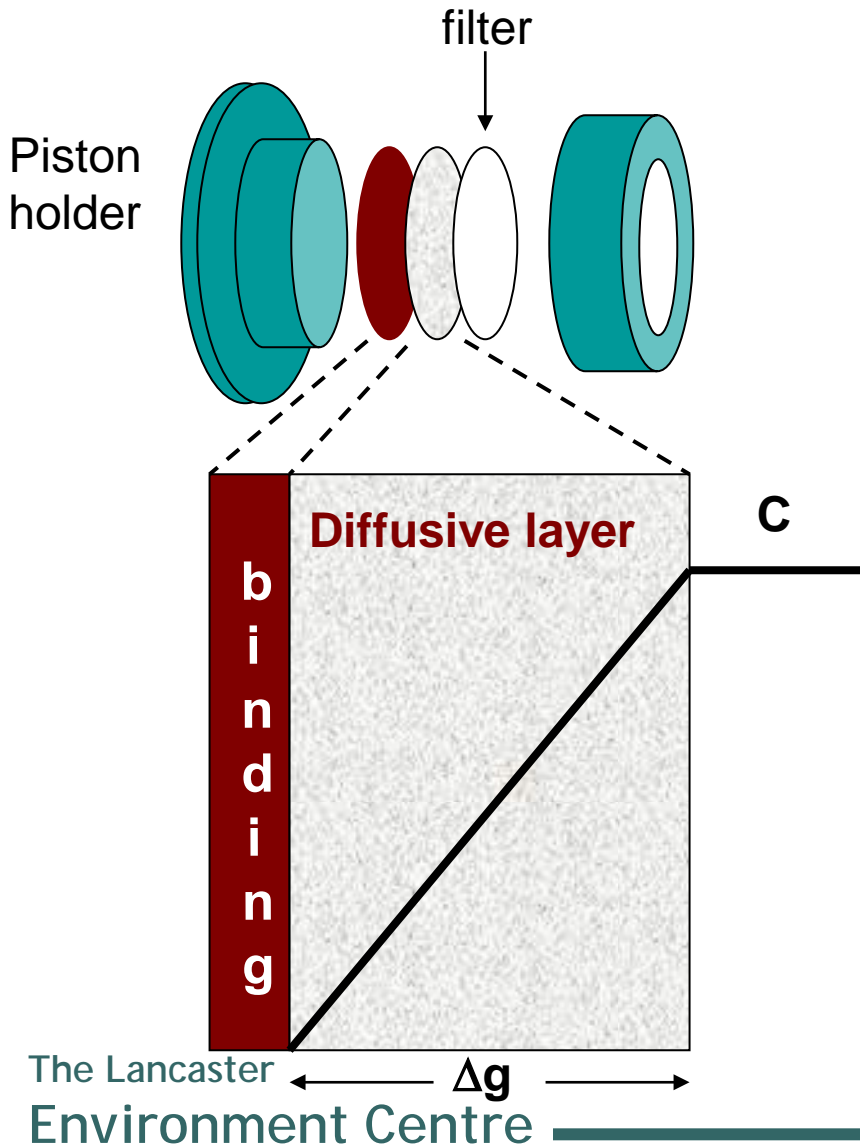


# Traditional Analysis

- Large volume sample, e.g. 2-20 litres
- Via LSC ( $\beta$  emission):
  - Complex purification required to remove other  $\beta$  emitters.
- Via ICP-MS:
  - Complex purification required to remove isobaric interferences (Ru, Mo).
- Yield tracer options limited (stable Re or  $^{99m}\text{Tc}$ , short-lived  $\gamma$  emitter).



# Diffusive Gradients in Thin Films



$$F = M/At$$

$$F = DC/\Delta g$$

$$C = M\Delta g/DAt$$

$$F = \text{flux (ng cm}^{-2} \text{ s}^{-1}\text{)}$$

$$M = \text{mass (ng)}$$

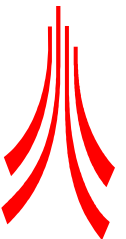
$$A = \text{area (cm}^2\text{)}$$

$$t = \text{exposure time (s)}$$

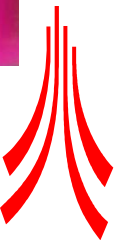
$$D = \text{diffusion coefficient (cm}^2 \text{ s}^{-1}\text{)}$$

$$C = \text{ng cm}^{-3} \text{ (ppb) / Bq l}^{-1}$$

$$\Delta g = \text{cm}$$

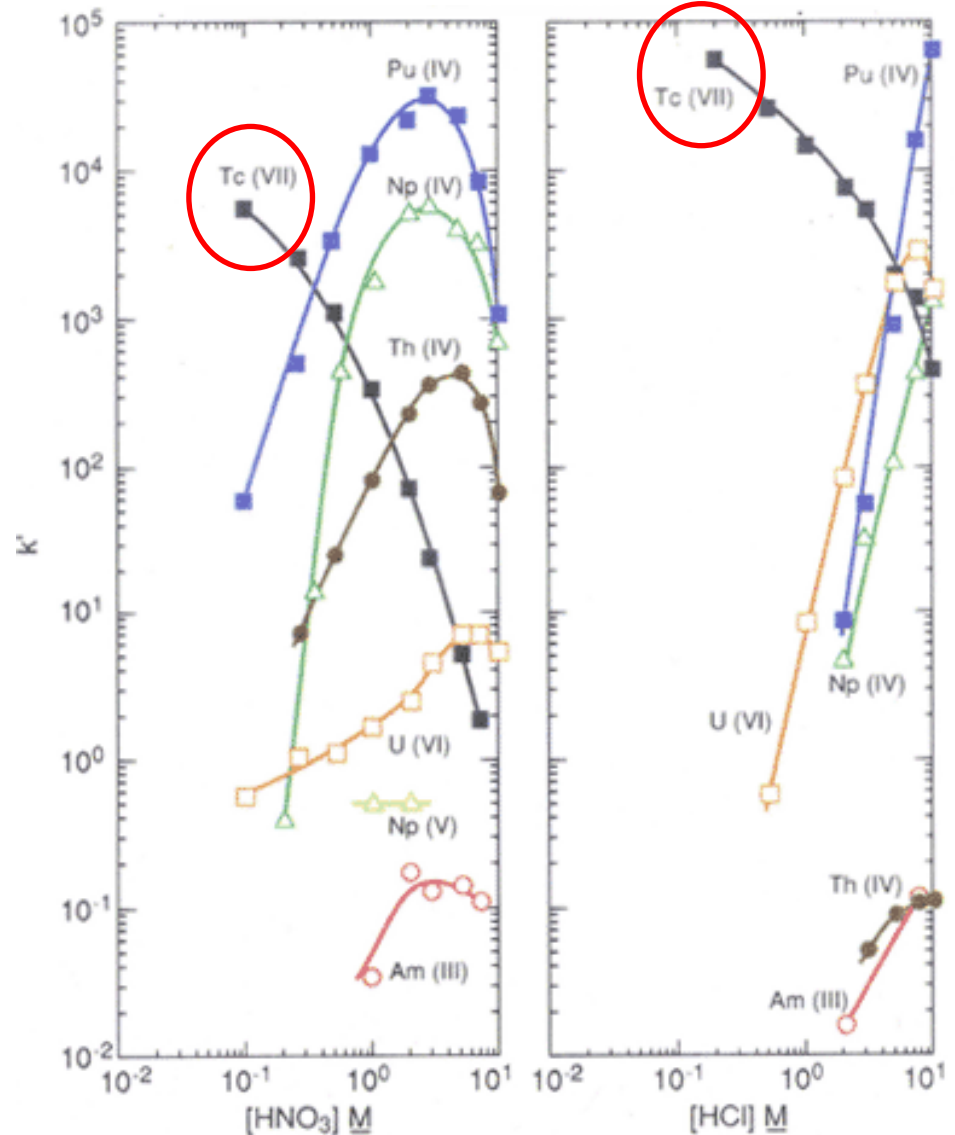


# Gel and Device

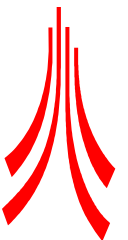


# DGT - TEVA

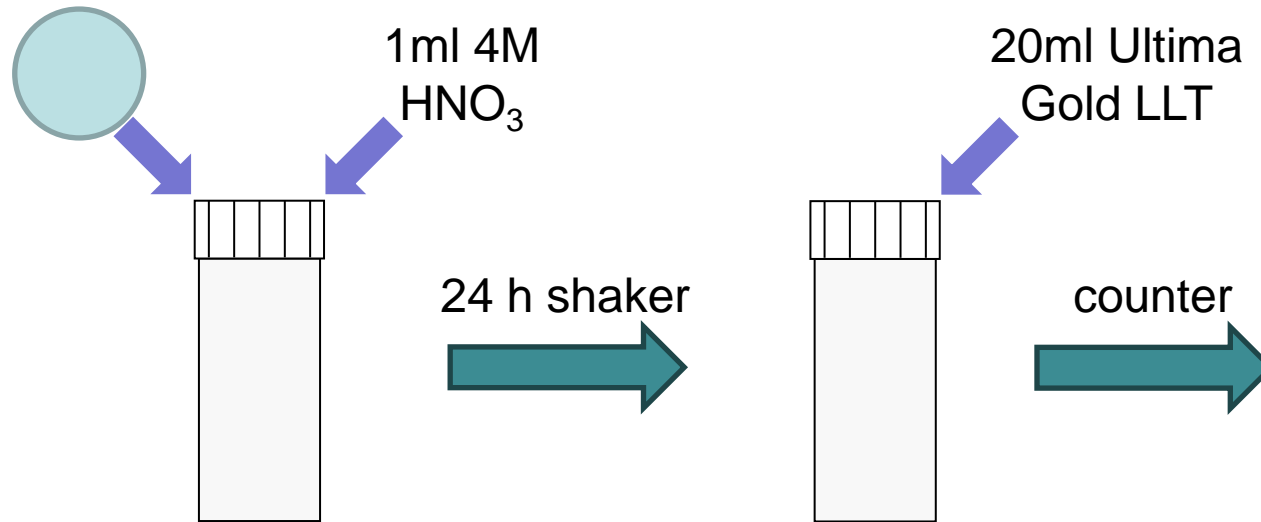
- TEVA selective for Tc at low acid concentrations.
- Potential to pre-concentrate and separate Tc in-situ.
- No need for yield tracer.



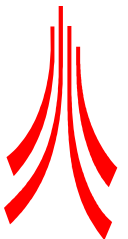
# Lab Deployments



# Analysis of Gels by LSC

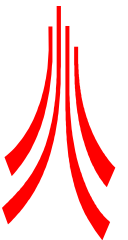
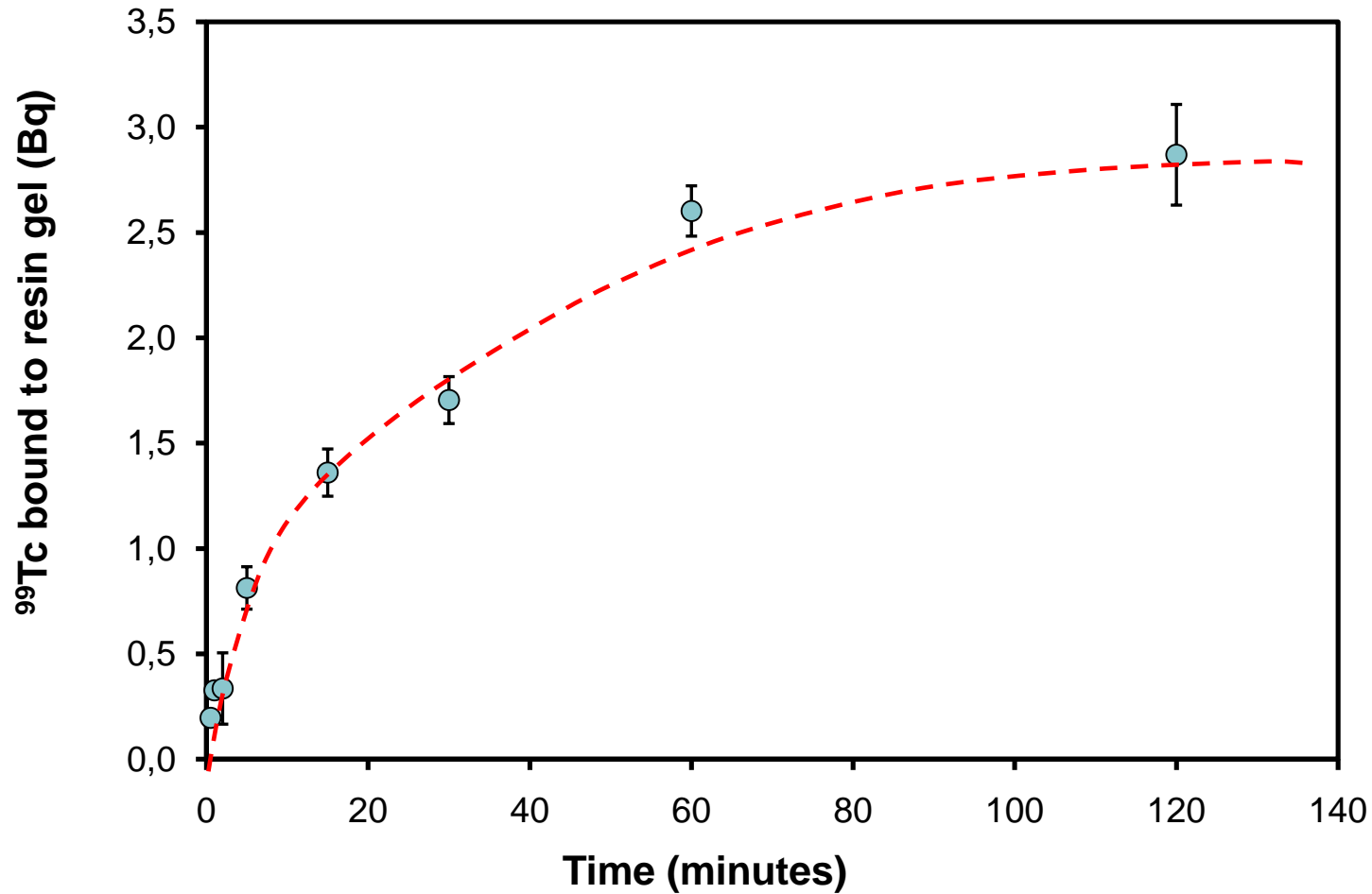


- Gel disintegrates in acid, allowing elution of Tc from resin
- Counting efficiency: 74.5    2.0%
- Uptake efficiency: 97.1    2.5%

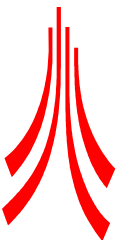
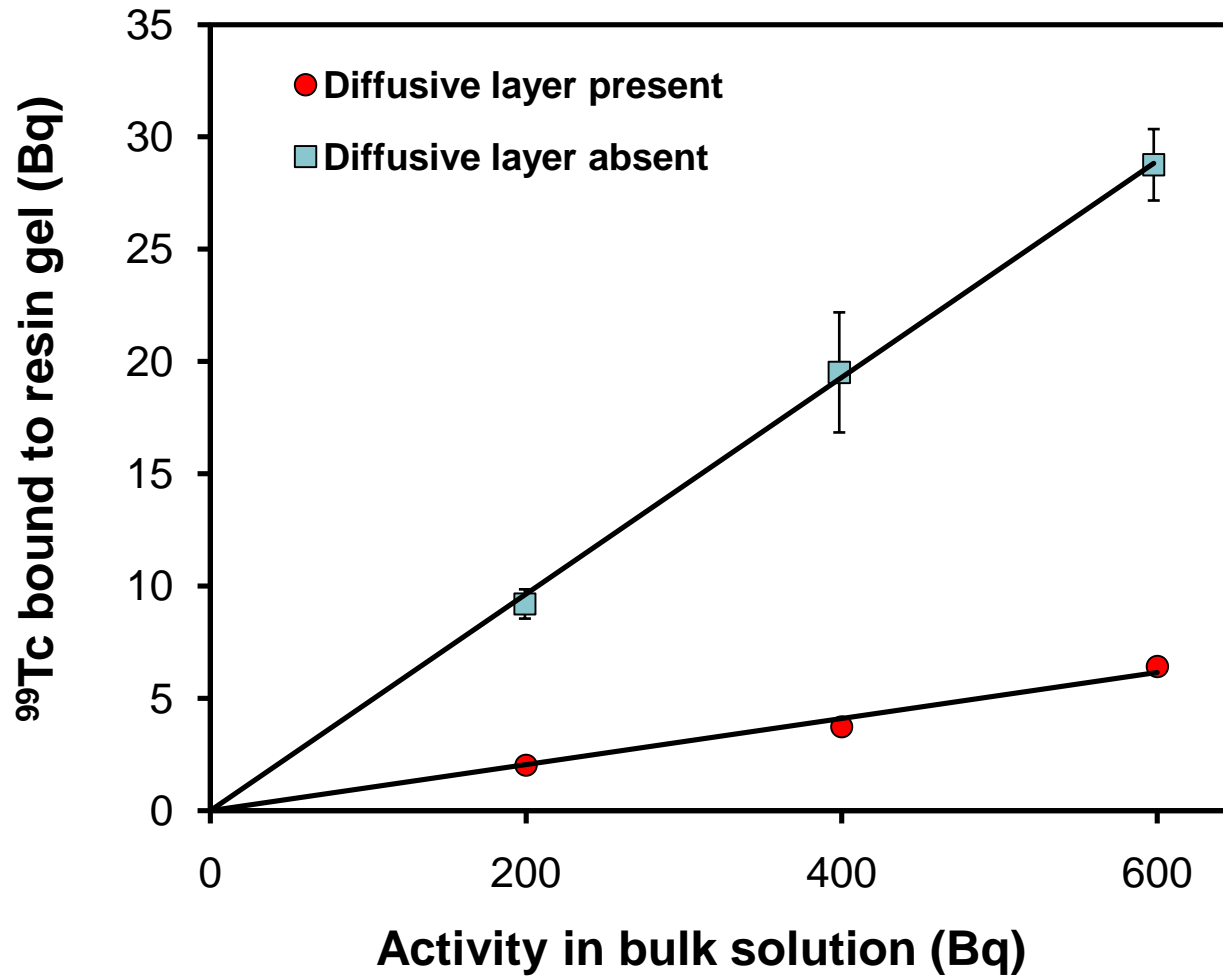




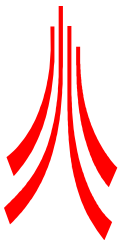
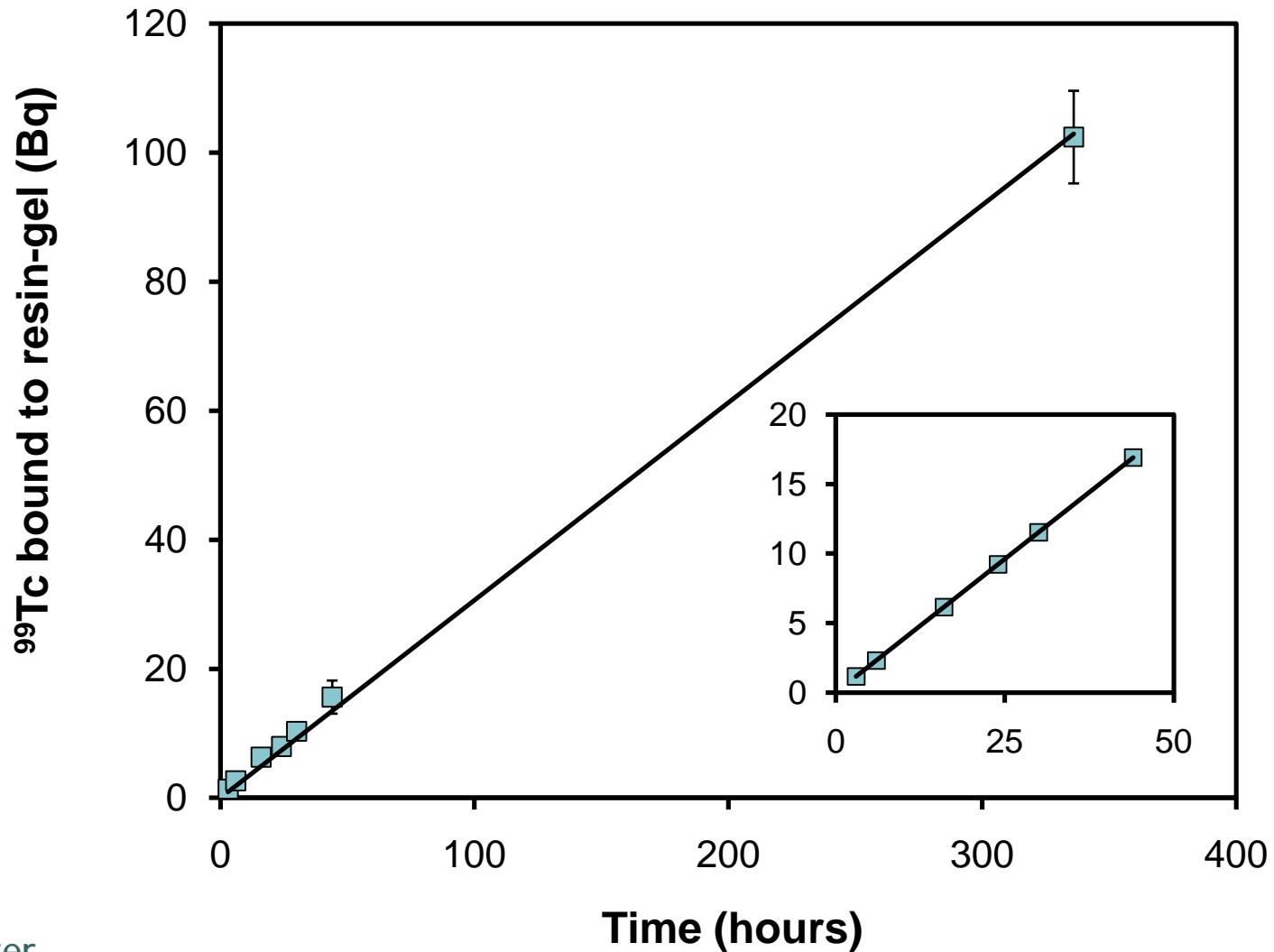
# Binding Kinetics



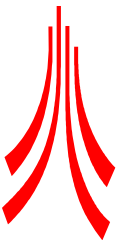
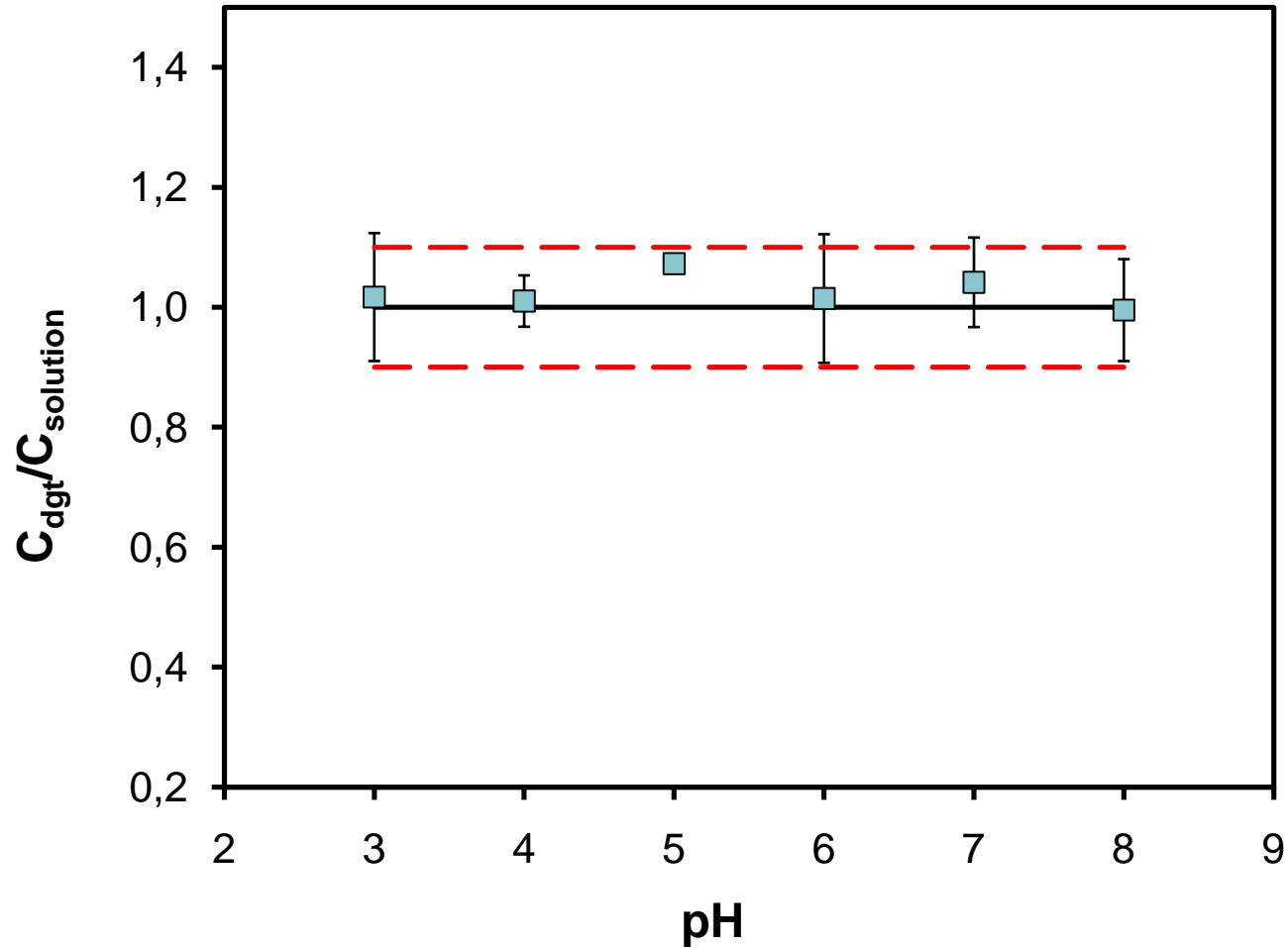
# Diffusive Layer Thickness



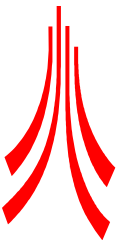
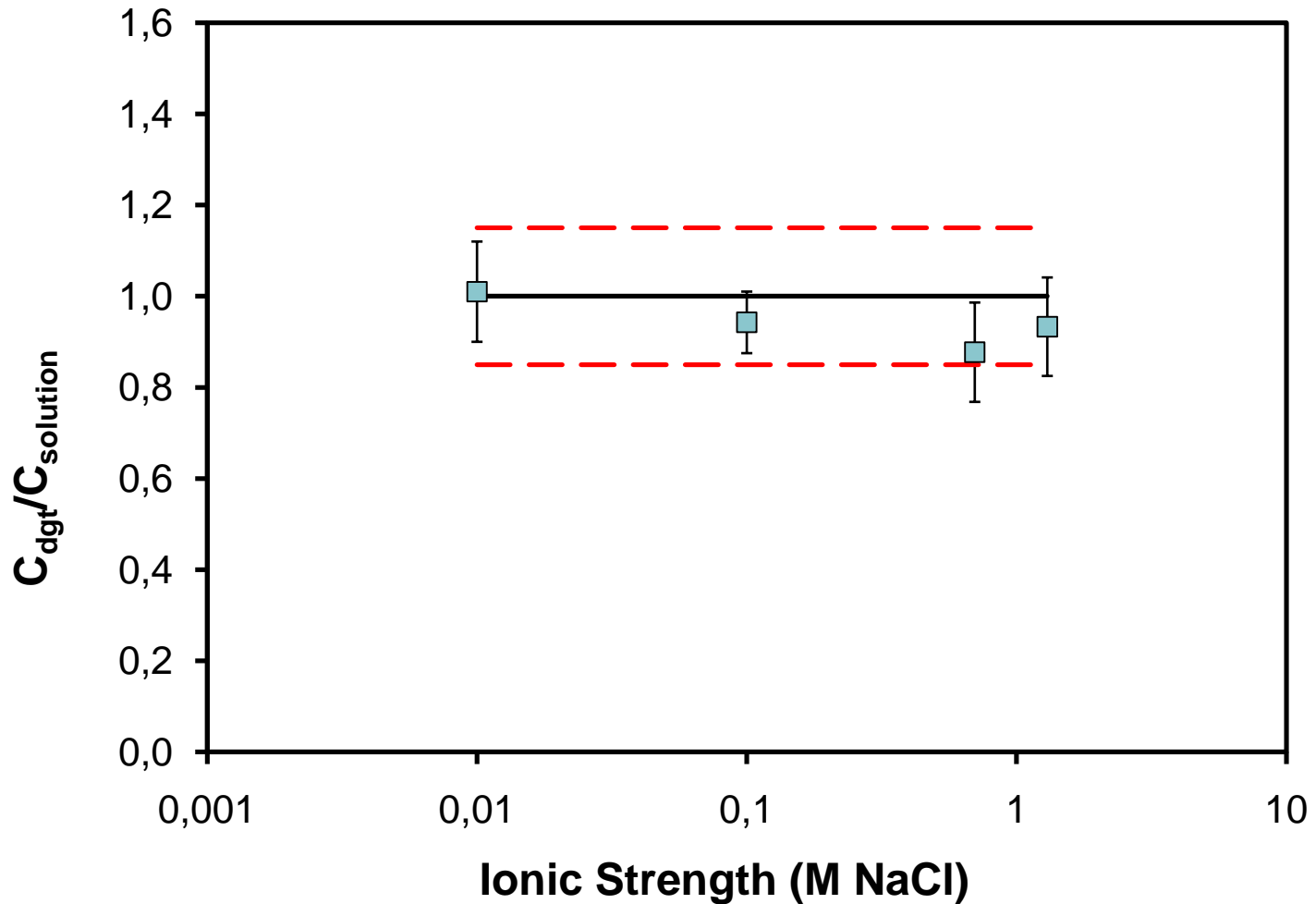
# Exposure Time



# Influence of pH

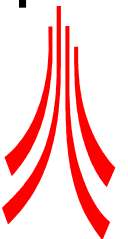


# Ionic strength

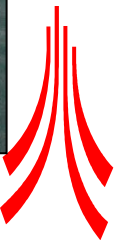


# Evaluation

- LSC analysis, count time = 400 mins, MDA =  $0.05 \text{ Bq l}^{-1}$  for a 2-week deployment.
- Lower MDA can be achieved through longer deployments and/or analysis by ICP-MS.
- Chemistry significantly simpler than traditional analysis, plus time-integration and speciation information available.



# Field deployment



# Further Work

- To date the method has been validated for seawater.
- Groundwater is a more complex matrix.
- Validation is needed for:
  - the presence of interfering major ions,
  - organic matter,
  - varying redox conditions.
- Collaboration with Triskem to optimise resin for environmental deployment.

