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Oxidative Capacity of the Geosphere

Sean Patrick Quigley, **Steven A. Banwart** & **David N. Lerner**

GPRG, F111A Mappin Building, Mappin St., Sheffield, S1 3JD, UK

Natural attenuation of hydrocarbon contaminated aquifers involves the reduction of contaminant mass and concentration through *in situ* biodegradation by indigenous subsurface micro-organisms. At sites where natural attenuation is significant enough to obviate the need for expensive techniques such as pump and treat, the cost of remediating contaminated aquifers may be substantially reduced. However, a potential limiting factor on natural attenuation is the availability of terminal electron acceptors (TEAs). Oxygen is quickly depleted in the aquifer environment due to transport limitations. Anaerobic conditions therefore predominate in hydrocarbon contaminant plumes. Under these conditions the availability of mineral oxidants may be a key control on biodegradation. Quantification of mineral oxidant availability under anaerobic conditions is therefore important for the assessment of capacity for natural attenuation in an aquifer.

The oxidative capacity (OXC) of a hydrocarbon contaminated Triassic sandstone aquifer, located north of Wolverhampton, UK was investigated using a Ti(III)-EDTA reductive dissolution assay (Heron et al., 1994). The measured oxidative capacity of the aquifer sediment could potentially remove 80% of the plume total organic carbon (TOC). However, site data indicates that a mere 0.1 to 2.5% of the TOC has biodegraded with concomitant iron reduction (Thornton, pers. comm.). The low rate of natural attenuation at the site may be due to lack of mineral bioavailability.

A number of mechanisms are described in the literature as potentially controlling the bio-availability of TEAs. These include thermodynamic stability of more crystalline iron oxide mineral forms, mineral surface area, passivation of the mineral surface by adsorbed or precipitated iron(II) species, presence of chelators or electron shuttling agents such as humic acids, presence of suitable indigenous dissimilatory iron reducing micro-organisms and factors affecting microbial adhesion (Lovley, 1991), (Urrutia et al., 1998), (Roden and Zachara, 1996), (Lovley et al., 1996), (Rijnaarts et al., 1996). Data from the site under investigation suggest that the lack of correlation between OXC and in situ biodegradation may be due to factors such as substrate toxicity (phenol concentrations as high as 1 400 mg/l have been found) or silicate coating of mineral oxides.

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