

Suspended floc: Links between microbial ecology, FeOOH and trace element dynamics

L.A. WARREN*, A.V.C. ELLIOTT AND J.M. PLACH

SGES, McMaster University, 1280 Main St West, Hamilton
ON L8S4K1 Canada

(*correspondence: warrenl@mcmaster.ca)

The linkages between microorganisms and geochemical processes in environmental systems hinge on ecological relationships associated with the microbial consortia involved. These ecological relationships are often highly cooperative and macroscopically structured to enable microscale redox cycling not favourable under bulk system conditions. Suspended floc, highly microbially active, trace element (TE) rich and interactive with bulk aqueous solution, are poorly studied with respect to microbial-mineral-TE biogeochemistry. Characterization of suspended floc TE abundance and partitioning for Ag, As, Cu, Ni and Co across six variably impacted aquatic ecosystems identify floc to be a key TE sequestration sedimentary compartment, concentrating TE ~55x above that of surficial bed sediments. Further, floc TE-geochemical partitioning patterns were conserved across systems, with amorphous Fe oxyhydroxides (FeOOH) consistently as the most important sorbent phase for TE retention, irrespective of physico-chemical conditions or TE involved. Results indicate that floc TE uptake is biologically linked to floc microbial components. Floc organic concentration directly predicts floc FeOOH concentration while imaging analysis shows bacterial exopolymeric substances (EPS) fibrils, a major floc constituent, to be heavily mineralized. Thus while floc FeOOH are the dominant floc TE sequestration phase, EPS and microbial constituents are the critical foundation underpinning floc TE behaviour through their structural role in floc FeOOH occurrence, ultimately creating a distinctly different solid than bed sediments with differing controls on TE uptake. Further, the enrichment of both iron reducing and iron oxidizing microorganisms from all flocs collected across a spectrum of systems widely variant in [O₂] and pH indicate previously unconstrained Fe cycling occurs at the floc scale that is controlled by floc ecology, not by system geochemistry. These results add to the growing evidence that ecological partnership enables consortial microbes to “sidestep” geochemical constraints predicted to occur at the bulk scale.

Carbonation of artificial silicate minerals: Passive removal of atmospheric CO₂

C-L. WASHBOURNE¹*, P. RENFORTH² AND
D.A.C. MANNING¹

¹School of Civil Engineering and Geosciences, Newcastle
University, NE1 7RU, United Kingdom

(*correspondence: carla-leanne.washbourne@ncl.ac.uk)

²Department of Earth Sciences, University of Oxford, Oxford,
OX1 3AN, United Kingdom

Artificial silicate minerals present an accessible source of material for enhanced weathering. Silicate ‘wastes’ may perform carbon sequestration through *in situ* carbonation of calcium (Ca) and magnesium (Mg) phases. Maximum carbon (C) capture potential using artificial silicates is 190-332Mt C a⁻¹ [1]. Soil engineering, promoting CO₂ sequestration by inclusion of these reactive mineral substrates, has the potential to capture a portion of the C turnover of the global pedologic system; 75 Gt C a⁻¹ [2][3][4].

Stable isotope data (δ¹³C, δ¹⁸O) confirm that >50-90% of C in pedogenic carbonates, formed on artificial silicates, is atmospherically derived. Field observations and laboratory data demonstrate that anthropogenic soils accumulate 20-30 kg C m² as carbonates (≥organic carbon content in natural soils). Flow-through experiments (25°C, 1 atm.) using fresh basic steel slag show pH buffered at ~11.6 as Ca leaches at a rate of log₁₀-8.9 – log₁₀-9.3 mol⁻¹sec⁻¹cm⁻², several orders of magnitude faster than ‘natural’ silicates. Once portlandite (Ca(OH)₂) has been consumed pH is reduced to ~9.1 and calcium carbonate precipitation continues.

Effective, low-energy field-scale implementation of mineral carbonation through soil engineering could assuage current constraints on economic performance [5][6][7]. Proof of principle for carbonation of artificial silicates in engineered soils has been demonstrated [4]; proof of field scale feasibility will be demonstrated through continued empirical and experimental observation including extensive analysis of carbon in urban soils at the Science Central development site, Newcastle upon Tyne, UK.

[1] Renforth *et al.* (2011), *Environ Sci Technol* **45** (6) 2035-41
[2] Schlesinger *et al.* (2000), *Biogeochem*, **48**; 7-20 [3] Manning (2008), *Min Mag*, **72**; 639-649 [4] Renforth *et al.* (2009), *Applied Geochem*, **24** (9) 1757-1764 [5] Butt *et al.* (1997), *Global Warming International Conference*, Columbia NY. [6] Huijgen *et al.* (2005), *Environ Sci and Technol* **39**: 9676-9682 [7] Lackner *et al.* (1997), *Energy Conversion and Management* **38**: S259-S264