Active capping and control of gas ebullition-facilitated contaminant transport

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Introduction: This talk will be on cost-feasible ways of sediment treatment, drawn from nearly two decades of remediation and active capping research from the United States west coast [1], east coast [2] and the Great Lakes [3-4]. Special focus will be on the Chicago River and the challenges faced in turning a highly polluted waterway into an aquatic greenway [5]. Our focus is on long-term uncertainty analysis through stochastic modeling [6-7], and the importance of gas ebullition in re-mobilizing pollutants from the sediment to the water column [8].

Methods: *Cap modeling:* Transport of 21 metals and organic contaminants through granular activated carbon (GAC), organoclay (OC), shredded tires, sand and apatite caps under diffusion and advection was modeled using deterministic and Monte Carlo simulations. Flux and concentration were normalized to acute toxicity criteria to compare results on a risk-normalized basis.

Gas ebullition: Gas ebullition was measured with gas collector systems placed at 14 sample sites. Glass wool traps were placed in each gas collector system to collect bubble-entrained particulates and non aqueous phase liquids to measure the ebullition-facilitated contaminant transport.

Results: Under diffusion, apatite and OC generally work best for most metals, based upon partitioning and sequestration mechanisms (particularly for the former). Under advection, OC performs best due to hydraulic control. GAC is almost totally ineffective for metals. For organics, tires work best under diffusion, but neither tires nor sand are likely to be effective under advection. Highly hydrophobic contaminants do not breakthrough any of the caps for decades to centuries under diffusion, and do not present toxicity concerns at the 95% confidence level (CL) after 100 years. Only GAC and OC were effective for lower molecular weigth PAHs and PCBs under advection, and performance was similar for these caps between diffusion and advection due to small observed diffusivities (D_{obs}). A general solution showing breakthrough time as a function of D_{obs} is presented demonstrating that methyl Hg, monoaromatics and naphthalene are not predicted to be sequestered well relative to their acute toxicity, thus representing a potential risk. Ebullition-facilitated metal fluxes were surprisingly large, with resultant fluxes of 10, 2, 6, 30 and 490 mg m^{-2} d^{-1} for Pb, Cr, Ba, Zn and Fe, respectively. These fluxes were 10-1000 times higher than predicted to occur by porewater diffusion from uncapped sediments, and on the order of advective porewater metal flux under a large hydraulic gradient of 0.05 m/m.

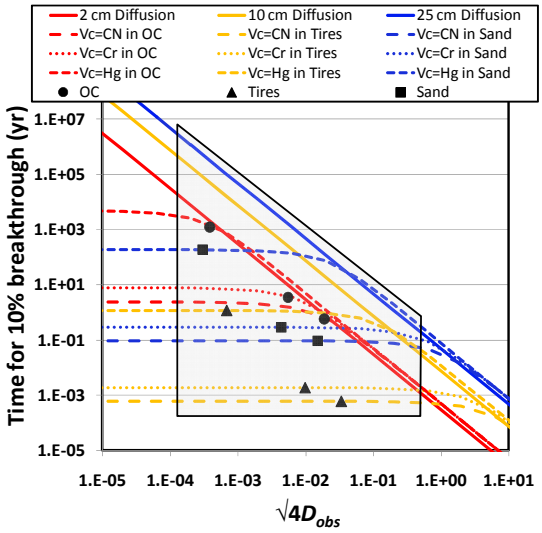

Fig. 1: Cap breakthrough as a function of observed diffusivity under diffusion and advection.

Discussion: Our research clearly shows that sediments with active gas ebullition cannot be considered candidates for "natural attenuation", as heavy metal and organic pollutant flux to the water column is comparable to advective flux from submarine groundwater discharge. It is our view that stopping biogenic gas production is not feasible, but controlling the contaminant flux is possible through active capping systems and high permeability engineered geo-products.

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