Advances in Amendments for Remediation: Where Are We Making Progress? (State of the Practice)

David T. Adamson (dtadamson@gsi-net.com) (GSI Environmental Inc., Houston, Texas, USA)

Background/Objectives. Amendment delivery strategies have evolved over the course of decades as in situ approaches became attractive alternatives to physical treatment processes and our list of contaminants of concern has continued to expand. Petroleum hydrocarbons saw an early focus on nutrient additions and air/oxygen sparging, and more complex amendments have rarely been considered. Chlorinated solvents have traditionally used a wider variety, including those focused on relatively slow biological reactions (e.g., carbon, microbes), more aggressive reactions (e.g., thermal, chemical oxidants), and even alternative delivery methods (PRBs). Metals, inorganics, and many emerging contaminants often require more unique strategies, including amendments that will stimulate sequestration rather than destruction. This presentation will discuss this progression as well as major advances in overcoming the current and future challenges associated with amendment delivery.

Approach/Activities. If contaminant treatment was purely a chemistry problem looking for a solution, then the overall effectiveness of amendment-based remediation would be based on solely the ability of the amendment to facilitate the targeted reaction. The reality is of course more complex and requires an engineering-based solution that ensures that there is contact between the amendment and the contaminant within a highly heterogeneous subsurface environment. This introduces a broad set of challenges, ranging from delivering amendments to contaminants in lower-permeability and fractured rock, low pH environments, amendment persistence versus contaminant degradation rates, and maintenance of proper geochemical conditions.

Results/Lessons Learned.
Luckily, there have been continued advancements in improving the effectiveness of amendments, both within the mature technologies that tend to dominate the industry as well as newer approaches. Promising approaches include:

- Use of high water volumes during substrate injection to improve contact (based on a better understanding of how amendments move following injection).
- Heat inputs that are designed to either stimulate contaminant biodegradation (low energy) or volatilization/destruction (high energy).
- Introducing fresh water as part of dynamic groundwater recirculation to improve capture.
- Shear-thinning fluids, interface-targeted emplacements, binding agents, wick drains, and other strategies designed to treat and/or reduce diffusion-based contaminant flux from low-permeability zones.
- Soil mixing to uniformly distribute amendments while controlling mass flux.
- Electrical current to direct movement of fluids and amendments, particularly in lower-permeability formations where injection is difficult.
- Promoting in situ biogeochemical reactions using sulfate, carbon, buffers, or iron.
- Improved site characterization methods and tracer tests to ensure that injected amendments will be distributed to the targeted zones.
- Large-diameter, “unpumped” wells filled with reactive media to focus the plume flow and increase treatment efficiency.

This list is not all-inclusive, but it demonstrates that much of the real progress has been in: (1) recognizing the importance of site geology in contaminant fate and transport; and (2) designing amendments and delivery strategies that address the challenges associated with geology.