Expedited Organo-Halide Destruction via Biostimulation without Augmentation Supported by Introduction of Abiotic Electron Donor

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Background: This paper presents concepts suggesting the biogeochemical tools to remediate a given Site biologically are present and, and regardless of the type of remedial input (amendment or augmentation) the results are ultimately dependent on the carrying capacity of the treatment zone (ecosystem) to distribute microbial biomass and support microbial growth and activity.

Strategy: Sites where baseline conditions support microbial growth, communication and biofilm formation prior to introduction of an input (additive) realize positive results with the input of an additive, whereas sites that are not supportive at baseline conditions, regardless of input, often fail to realize performance expectations. Are the results reportedly achieved serendipitously? Unfortunately, logistic, and financial limitations, sediment/soil/groundwater-associated microbial components are not properly tracked over space and time.

Conversely, sites where the nutritive capacity is depleted, scavenged by anthropogenic introduction of excessive amounts of PHCs/cVOCs, input(s) often don't work because the subsurface system did not have the carrying capacity to allow microbial growth and/or activity. Industry conclusion is additive failed.

Dr. William Costerton in his 1965 classic 'The Biofilm Primer' stated, pages 76-77, 'Bacteria are unique in their ability to adapt to starvation by forming UMB that preserve their genome and persist for very long periods of time in nutrient-deprived environments. They are equally unique in their ability to rapidly mobilize appropriate genomes into custom-made communities that can respond to nutrient opportunities, including those offered by cathodic metal surfaces from which electrons can be harvested'.

Process: To evaluate the effect of abiotic input to a biostimulated microcosm a 28-day study was performed. Microcosm 1 used the biostimulant **ERD**ENHANCED as the sole electron donor. Microcosm 2 contained approximately 8% by weight Hogänäs Sri5 metal in the **ERD**ENHANCED to serve as an electron donating 'pump' (input). Both microcosms augmented with dehalorespiring consortium KB-1.

An accompanying on-site proof-of-concept study was performed to determine if results of the microcosm study were transferable to the field. Two monitoring wells were amended with respective microcosm additive formulations; MW-23A with **ERD**ENHANCED as the sole electron donor, MW-24A the combined formulation. Baseline TCE MW-23A 28,900 µg/L with Parent-Parent Daughter Ratio (P:PD) 56%; MW-24A baseline TCE 176,000 ug/L with P:PD at 89%. Contaminants in saturated highly fractured bedrock sandstone. Groundwater was monitored every 6 weeks for 18 months.

Results: The laboratory study documented combined biotic/abiotic microcosm enhance the supportive capacity of the ecosystem by expedited expression of autoinducing signaling

molecule AI-2 (communication), the presence of protein (biofilm), and complete tetrachlorethylene (PCE) biotransformation.

Six-week post-initial amending processes [TCE] decreased >99% at both locations. [TCE] remained BDL at MW-24A throughout the evaluation. [TCE] at MW-23 increased slightly at month 4-5; however, realized >99.99% reduction [TCE] in month 18 and three order of magnitude increase [Ethene] at month 10. Overall MW-23A realized >99.99% reduction [TCE], 78.6% reduction cis-DCE, 98.4% reduction VC, all from peak bioavailability.

MW-24A realized >99.9% reductions in TCE, cis-DCE and VC with 10^5 increase [Ethene] at month 6. The field evaluation confirmed results of the microcosm evaluation were transferrable to *non-augmented* field conditions and addition of abiotic electron donor enhanced bioremediation and microbial activity.

Conclusion: Biofilms constitute the predominant mode of terrestrial growth. Biofilm microcolonies align themselves to optimize metabolic cooperation and efficiencies. We suggest the nutritive capacity of the ecosystem and its ability to support microbial growth, distribution, communication and biofilm formation is paramount to realize sustainable and maximum microbial performance, regardless of who is there and how many are there to start.