Laboratory Experiments of Smouldering Combustion as a Remediation Technology for Contaminated Soil

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1.0 INTRODUCTION

Self-Sustaining Treatment for Active Remediation (STAR) is an innovative technology that has significant potential for the remediation of sites contaminated by non-aqueous phase liquids (NAPLs).

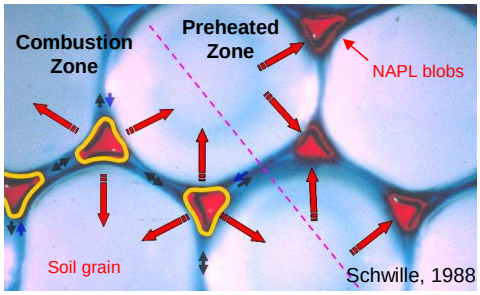

Fig. 1 – The inert porous medium (soil) traps the heat generated by the smouldering reaction, effectively preheating the NAPL fuel ahead and increasing the efficiency of the reaction as it proceeds.

STAR employs smouldering combustion of NAPL within the soil to destroy the contamination. Once smouldering is initiated, the ignition source may be extinguished and the combustion front may continue to propagate through the NAPL-contaminated porous media provided sufficient oxidant is supplied to support the reaction. Therefore the combustion front has the potential to follow the NAPL distribution (self-targeting) without further energy input (self-sustaining).

2.0 EXPERIMENTAL WORK

Smouldering combustion experiments have been conducted at the small (~10 cm) and intermediate (~30 cm) scales on a range of fuels and with different soil types, fluid saturations and source configurations. Air was used as the oxidant.

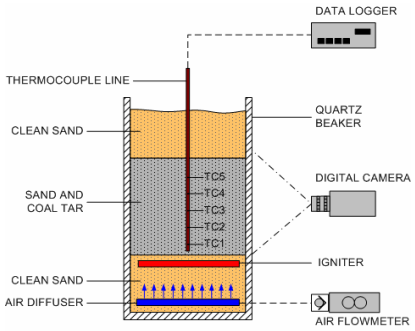

Fig. 2 – The small scale apparatus

Coal tar in Coarse Sand (base case)

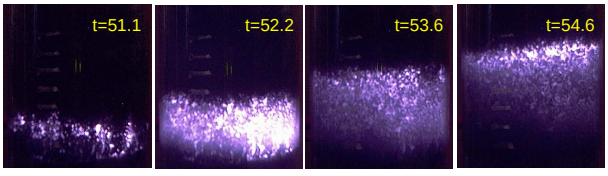

Fig. 3 - A series of images showing the onset and propagation of the smouldering reaction in a small scale experiment. Times are in minutes, ignition occurred at t=50.

TABLE 1. EXAMPLES OF SMALL SCALE TESTS PERFORMED

Category	Soil type	Contaminant	$T_{ignition}$ (°C)	T_{max} (°C)	$t_{ignition}$
Base Case	Coarse sand	Coal tar	400	1032	57min
Vary Contaminant	Coarse sand	Vegetable oil	203	786	44min
	Coarse sand	DCA	200	688	22min
	Coarse sand	TCE	350	689	24min
	Coarse sand	Dodecane	240	660	32min
	Coarse sand	30% solid explosive	192	370	58min
Vary Porous Media	Fine sand	Coal tar	400	822	23min
Vary Fluid Saturation	Coarse sand	30% Coal tar 70% Air	400	715	48min
	Coarse sand	60% Coal tar 40% Water	470	1040	47min
Heterogeneous Source Zone	2 layers	Coal tar	425	1139	43min
	3 layers	Coal tar	400	1139	47min
Field Samples	Peat	Field coal tar	300	1010	47min
	Fine sand	Field coal tar	250	1053	52min
	Oil sands	Solidified petroleum	300	1066	35min

3.0 EXPERIMENTAL RESULTS

The propagation of the smouldering front can be followed using thermocouple traces. The observed rate of propagation ranged from 2 cm/hr to 60 cm/hr depending on the fuel studied and the air flow.

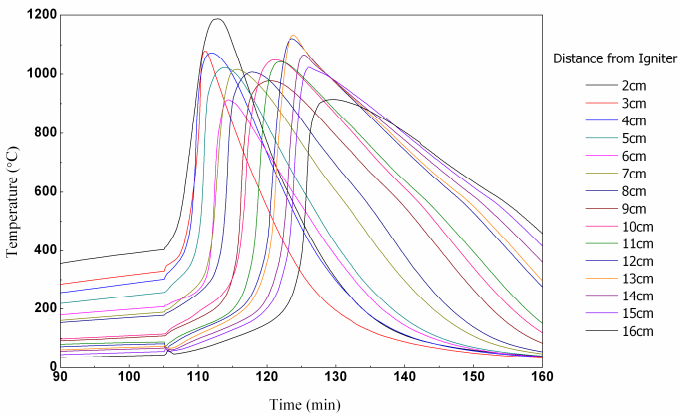

Fig. 4 - Temperature histories recorded during a typical experiment at the intermediate scale

CHEMICAL ANALYSIS RESULTS

To evaluate the effectiveness of the process as a remediation technique, post-treatment analysis were conducted on soil taken from the core and from the periphery of the sample, here referred to as “inside combustion zone” and “outside combustion zone”.

	Amount Reduced	
TPH (GC-MS)	99.9+%	98%
PAH (GC-MS)	99.9+%	95%
Volatile BTEX (GC-MS)	100%	100%

ACKNOWLEDGEMENTS

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