

## Optimising the biopiling of weathered hydrocarbons within a risk management framework - PROMISE

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### INTRODUCTION

Thirty years of research into petroleum microbiology and bioremediation have bypassed an important observation – that many hydrocarbon contaminated sites posing potential risks to human health harbour weathered, ‘mid-distillate’ or heavy oils (Pollard, 2003). *Ex-situ* biopiling is an important technology for treating soils contaminated with weathered hydrocarbons. However, its performance continues to be represented by reference to reductions in the hydrocarbon ‘load’ in the soils being treated, rather than reductions in the risks posed by the hydrocarbon contamination (Owens and Bourgouin, 2003; Tien et al., 1999). The absence of ‘risk’ from the vocabulary of many operators and remediation projects reduces stakeholder (regulatory, investor, landowner, and public) confidence in remediation technologies, and subsequently limits the market potential of these technologies. Stakeholder confidence in the biopiling of weathered hydrocarbons may therefore be improved by demonstrating process optimisation within a validated risk management framework.

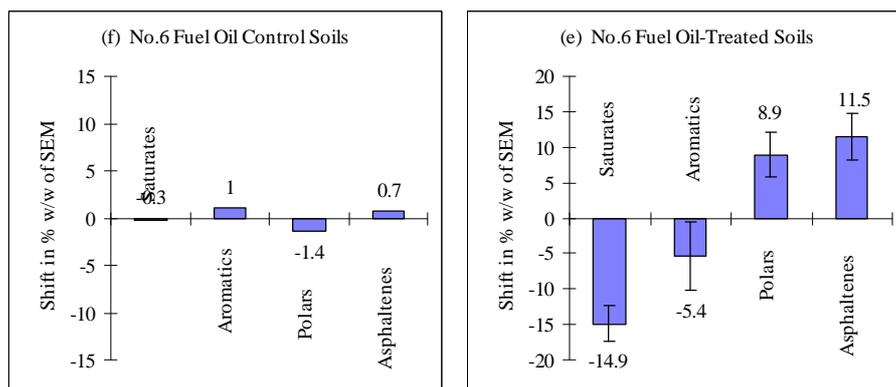
To address these issues, a consortium led by Cranfield University’s Integrated Waste Management Centre has secured funding from the Government’s Bioremediation LINK programme. Project PROMISE (involving BP, SecondSite Regeneration Ltd., Dew Remediation Ltd., TES Bretby (Mowlem Group), technology translators PERA, and academics from Aberdeen, Cranfield and Lancaster Universities) aims to improve market confidence in biopiling by demonstrating how this treatment may be applied within a risk management context.

### RISK MANAGEMENT

For weathered hydrocarbon wastes, risk management decisions are complicated by the gross complexity of the source term and the effects of weathering on the bioavailability of risk-critical compounds. There are also significant inter- and intra-variability in site conditions and resulting remediation success. For the heavy oils (equivalent carbon (EC) >20), losses due to biotic and abiotic weathering processes may result in compounds with increased hydrophobicity and recalcitrance (Figure 1). These compositional changes dramatically affect the affinity of the weathered wastes for risk-critical compounds such as polynuclear aromatic hydrocarbons (PAH) prior to, during and following biological treatment. These chemical processes are only partially understood.

#### Risk management frameworks

The regulation of site remediation now requires adoption of a risk-based approach. Subsequently, verification of remediation technologies should take place within this framework. For petroleum hydrocarbons in the soil, international regulatory guidance on the management of risks from contaminated sites is now emerging. Much of this promotes the use of risk management frameworks to guide decision making, application of reference analytical methodologies and the derivation of toxicological criteria (acute, sub-chronic, chronic) for these wastes. The Environment Agency of England and Wales have now published their risk management framework for petroleum hydrocarbon in soils. Part of this research will be to critically evaluate philosophical differences between US, European and Australian approaches to risk management for petroleum hydrocarbons (Table 1) and implications for selection of analytical and exposure assessment methods.



**Fig. 1. %<sup>w</sup>/w changes in the class fractions of solvent-extractable matter (SEM) isolated from control (f) and biologically treated (e) No. 6 fuel oil after 256 days treatment in soil microcosms.**

**Table 1. Some characteristics of regulatory approaches to evaluating the risks to human health from petroleum hydrocarbons in soil (Environment Agency, 2003)**

Basis of approach	TPHCWG / RIVM	MADEP
Staged approach	Total petroleum hydrocarbon criteria working group (TPHCWG) and Dutch Institute for Public Health and Environmental Protection (RIVM) approaches assess indicator compounds first and, if necessary, progress to consideration of the (non-carcinogenic) effects of TPH fractions.	Requires assessors to look at both indicator compounds (target analytes) and (non-threshold) effects of petroleum fractions.
Defining fractions	RIVM and TPHCWG base fractions on equivalent carbon numbers (EC <sub>n</sub> )	MADEP base fractions on carbon numbers
Combining fractions	TPHCWG and RIVM combine risk-based screening levels (RBSLs) for all fractions to give an overall petroleum RBSL	Under the MADEP scheme, the RBSL for each fraction is regarded as independent
Indicator compounds	RIVM and TPHCWG consider all compounds (including indicator compounds) in the EC range when assessing the (non-threshold) effects of petroleum fractions	MADEP specifically exclude the indicator compounds from the consideration of the non-threshold effects of TPH fractions

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