Commercial Activities in Remediation of Soil and Sediments and Trends in the Asia Pacific Region

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Introduction

Countries in the Asia Pacific region have not been recognised internationally as developers and widespread users of technologies for soil, sediment, and groundwater remediation. Rather, countries in the region have relied on adopting remediation technologies for soil, sediment, and groundwater remediation. Rather, countries in the region have relied on adopting remediation technologies and approaches developed in the Northern Hemisphere, and this approach has largely been successful. Trends in research and practice in the field of soil, sediment and groundwater remediation, indicate that there is relatively less reporting of international cooperation and development of remediation technologies in the Asia Pacific region compared with the Northern Hemisphere. The major barriers to adoption of such technologies have been the requirement for low implementation costs, and those regulatory agencies in the region have taken a non-prescriptive approach to enforcing contaminated site assessment and remediation. Unlike programs in the Northern Hemisphere (e.g. the Superfund Program in the US) where there has been special funding for the development of innovative technologies, there has been relatively little financing available for similar activities in Asia Pacific countries. Two case studies from Australia are presented on the commercial adaptation and application of (1) permeable barrier technology (for contaminated soil and groundwater) and (2) bioflushing of marine sediments contaminated with petroleum hydrocarbons. These case studies represented cost effective applications of previously well developed technologies and approaches.

Keywords: Asia Pacific Region; Australia; bioremediation; groundwater remediation; marine sediments, bioflushing; permeable barriers; sediment remediation; soil remediation; surfactants

1 Methodology

1.1 Assessment of industry trends in soil, sediment, and groundwater remediation

The outcomes from two international conferences on site contamination assessment and remediation covering soil, sediment and groundwater, were examined. These conferences were described as follows:

(1) The Contaminated Soil conference held in Edinburgh in May 1998. This is a comprehensive international forum on site contamination issues, held every 2-3 years since 1985, and represents Northern Hemisphere developments and practise in this field. A content analysis was conducted of the 400 presentations.

(2) The Contaminated Site Remediation Conference held in Western Australia in March 1999. This forum reported projects in site contamination and remediation, and particularly those in the Asia Pacific region. It also reported studies on developments of new assessment and remediation technologies. Content analysis was also conducted of the 107 reports presented.
1.2 Sediment bioflushing case study

1.2.1 Background

In mid-1994, ~4000 l of diesel fuel was spilled at an earthmover refueling bay at an Australian port, in a tropical marine environment. The refueling bay was constructed 8 m above sea level, on a rockfill, battered steeply to the high tide mark. Receding tides exposed 25 m of gently sloping, rocky intertidal zone. The rockfill's solid construction, however, precluded excavation to prevent further pollution of the sea. Contaminated shoreline sediments comprised fine silts, fine and coarse sands, coral fragments, skeletal particles, shattered shells, pebbles and stones, overlain by rocks of up to 1 m in diameter. There were six sampling times over the period of the project. Samples were taken as grab samples (0-200 mm depth) from the sediment material (representing the 40 m² contaminated area). This intractable rock covering, strewn over the contaminated intertidal zone, resisted extraction of comprehensive borehole data, needed to define the petroleum hydrocarbon (also referred to as Total Residual Hydrocarbon, TRH, in this paper) plume and impeded access for sampling and clean-up activities.

1.2.2 Analysis and site characterisation

Sample analyses included pH, electrical conductivity (EC), available nitrogen (N) and phosphorus (P) [3], heterotrophic and hydrocarbon degrading microbial populations [4], and the GC-MS and GC-FID analyses for Total Residual Hydrocarbons (TRH) and biomarkers [5]. Since contamination concentrations immediately after the spill were unknown, representative sediment samples were saturated with diesel and freely drained, to estimate 'diesel holding capacity' of the sediments and hence maximum possible TRH concentrations at Week 0.

1.2.3 Remediation strategy

A non-invasive clean-up strategy was designed to prevent further discharges to sea, remove residual diesel from the rockfill and to enhance natural biodegradation processes, already present in the shoreline sediments. Biosurfactant (called Biosolve®; a proprietary surfactant CAS #: 138757-63-8; used at the recommended rate), and soluble N:P:K nutrient formula, were flushed into the rockfill via an agricultural drain at the spill site, to disperse and flush remaining diesel into shoreline sediments. Related approaches to soil contamination have previously been described [6]. A floating absorbent boom was used to prevent petroleum hydrocarbon escape to sea, although no discharge was observed during the flushing periods. Biosurfactant and soluble N:P:K nutrient formula were also sprayed over the rocks and sediments in the intertidal zone and slow release (5-6 months) N:P granules (MaxBac® Slow Release formulation) were distributed to all accessible areas of sediment. Rockfill flushing was repeated at Week 121, 131, 177 and 183, with shoreline spraying and nutrient placement at Week 132, 173, 177 and 183. Treatments were interspersed with sampling and analyses of the impacted sediment to monitor progress.

1.3 Permeable barrier (funnel and gate system) case study

1.3.1 Background

In the second case study, a petroleum hydrocarbon spill occurred at an industrial facility in South Eastern Australia in December 1997. This volatile petroleum hydrocarbon (predominantly C_{19-41} alkanes) was used routinely as a solvent at the facility. Due to leaking storage tanks, this product permeated throughout the soil at the facility with a portion entering a nearby river. A permeable barrier (i.e. funnel and gate system), for treating petroleum hydrocarbon contaminated groundwater, was constructed at the site using the previously described methodology [7,8]. Groundwater flow directed towards the gate was subject to two treatment processes applied in sequence, in order to effect the highest possible reduction in petroleum hydrocarbon concentrations in effluent groundwater:

(1) sparging and
(2) adsorption and biodegradation using a mixture of blended peats.

1.3.2 Construction of funnel and gate system

The system was comprised of an impervious barrier membrane (i.e., the funnel), directing groundwater into the treatment area (i.e., the gate). The gate consisted of a sparging unit up-gradient of the peat materials. The funnel component, designed to intercept the contaminant plume before it entered the nearby river, consisted of a 0.75 mm thick High-Density Polyethylene (HDPE) impervious barrier membrane positioned vertically in the cut-off trench to capture and redirect incident groundwater over the length of the spill area, parallel to the nearby river. This was constructed using the methodology already described [8]. The gate was composed of sequential treatment systems comprising a sparging unit emplaced in basaltic scoria, followed by blended peat materials. The funnel was designed to intercept groundwater flow from areas directly down-gradient of the spill site, as well as adjacent areas in which lateral migration of the plume may be occurring. The dimensions of the funnel trench are 27 m long × 5 m deep x 0.6 m wide, excavated to a level of 0.5 m below the fill-natural siltstone interface.

1.3.3 Sparging component of the barrier trench

The section of the gate that initially encounters influent groundwater consists of a volume (~5 m³) of porous basaltic scoria. The scoria was emplaced over a submerged, perforated air sparging pipe, creating finely disseminated air bubbles which permeate the water column within the gate and thus delivering oxygen to enhance biodegradation. Air was supplied to the system by a 12-cfm compressor, supplying 0.9 m³/hr of air per hour. The sparging apparatus was set up to minimise losses of petroleum hydrocarbon by volatilisation.

1.3.4 Peat Component of the permeable barrier

Subsequent to groundwater sparging using the above method, groundwater within the gate passed through a peat mixture (30 m³), immediately down-gradient of the sparging system.