TDP 6 - Biopile Field Demonstration at the Avenue Coking Works

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Introduction

Avenue Coking Works in Wingerworth, Chesterfield was in operation for over 40 years producing smokeless fuels and associated coal carbonisation by-products. These operations have caused extensive land contamination which will require remediation if the site is to be redeveloped. The three main primary sources of contamination are: a waste tip containing builders rubble, metal and coal gasification derivatives; a lagoon; and a contaminated plant area. Contaminants of major concern for all three locations include polycyclic aromatic hydrocarbons (PAH); phenols; mineral oil; benzene, toluene, ethylbenzene and xylene (BTEX); and cyanides.

Jacobs Babtie (now Jacobs) was commissioned by East Midlands Development Agency as principal consultants in the remediation and redevelopment of the 98 hectare site. A detailed site investigation involving approximately 135 boreholes and 320 trial pits has been undertaken at the site. A programme of field demonstrations was carried out to assess a number of remedial technologies, including bioremediation. Following a tendering procedure, a contract to undertake a field trial of solid phase bioremediation using biopile technology was awarded to DEC NV, a company headquartered in Belgium with UK operations located in East Grinstead, West Sussex. The aim of the trial was to assess the bioremediation potential of the waste tip and plant areas of the site.

DEC NV chose to demonstrate the potential for bioremediation using biopile technology and a three phased approach was designed for the trial. The first two phases were laboratory-based and consisted of a slurry biodegradation test followed by a bench-scale bioreactor test. A third phase field-scale trial was designed using results from the laboratory tests and this is the focus of this report.

Spraying the biopile with water

Method statements and health and safety procedures were prepared and approved and regulatory approval was received from the Environment Agency (EA).

During 2001, slurry biodegradation tests were conducted between April and August, bioreactor tests between July and September and the field trial from July to October. The field trial was performed within a purpose-built enclosure on the concrete hardstanding of the former coke stocking area at the Avenue Coking Works. Chemical analyses were performed by ALcontrol Laboratories, located in the UK and Holland.

Purpose and Objectives

The purpose of the field trial was to help assess the technical and economic performance of an *ex situ* biopile technology that might be applied as part of the full-scale remediation of the site.

The purpose of this report is to describe the design and construction of the active biopile and provide an objective assessment of the performance of the technology. Specific objectives include:

- A description of site characteristics including the nature and distribution of contaminants
- A description of the design and operation of an *ex situ* biopile
- An assessment of the technical performance of *ex situ* active biopile technology
- An assessment of system costs.

Conclusions

1. Laboratory-based treatability studies were used to help design the biopile field trial. Four test materials representing the waste tip and plant areas of the site were characterised to determine if they were suitable for bioremediation and this was followed by slurry biodegradation tests and solid phase bioreactor tests.

2. No particular nutrient treatment was more successful than another in promoting biodegradation. Data from the respiration measurements indicated that waste tip (TP344) and plant area (1084A) samples had the greatest potential for biodegradation and these samples were chosen for further testing in bench-scale bioreactors.

3. The bioreactor test on the waste tip (TP344) and plant area (1084A) materials confirmed the results obtained during the slurry biodegradation test. Volatilisation of some contaminants was significant for the waste tip (TP344) material.

4. A field-based active biopile demonstration was performed between July and October 2001. Approximately 20m^3 in total of waste tip and plant area material were used to construct separate sections of the biopile which was located inside a specially constructed shed. Operating inside a shed allowed greater control over moisture levels and the rate of injection of air into the biopile and also gave the ability to monitor gaseous emissions from the biopile.

5. At the start of the biopile demonstration, the contaminated material was pre-treated with a commercial nutrient formula and then mixed using a mechanical excavator. Samples were collected for analysis at the start and every two weeks. The biopile was sprayed with water three times a week to keep the moisture content at approximately 70%.

6. At the end of field trial, total PAHs in the waste tip material had reduced in concentration from 6,400 mg/kg to 3,346 mg/kg (48%). Biodegradation was more pronounced for "light" PAHs than for "heavy" PAHs like benzo(a)pyrene. BTEX concentrations reduced from 2.5 mg/kg to 0.036 mg/kg (98.6% reduction). Total phenol concentrations reduced from 9.82 mg/kg to 0.64 mg/kg (93%). Mineral oil concentrations showed no reduction during the trial.

7. At the end of the field trial, total PAHs in the plant area material had reduced in concentration from 13,916 mg/kg to 8,155 mg/kg (41%). Similarly to the waste tip material, biodegradation was more pronounced for "light" PAHs than for "heavy" PAHs. BTEX concentrations reduced from 101 mg/kg to 0.75 mg/kg (99% reduction). Total phenols concentrations reduced from 4.3 mg/kg to 1.04 mg/kg (76%). Mineral oil concentrations showed a slight reduction from 1,644 mg/kg to 1,417 mg/kg (14%).

8. The biopile was enclosed by a shed and volatiles were captured and treated by activated carbon. During the trial all measurements for BTEX, VOC, naphthalene and total phenols were below detection limits, both above the biopile and in the air discharged from the shed.

9. The addition of activated sludge to part of the biopile that was constructed of plant area material resulted in no difference in degradation compared to those areas that did not receive this treatment, suggesting that the soils contained sufficient

contaminant degrading microbes.

Lessons Learned

1. A respiration test is the ideal test to determine whether bioremediation has stopped. A respiration test within the laboratory tests therefore gives a good idea of when further biodegradation can no longer be expected within the full-scale test. However, within the respiration test this end concentration is achieved within a shorter timeframe, due to more favourable conditions.

2. To achieve maximum reductions in contaminant concentrations may require the biopile to be operated for longer than the 13 weeks duration of the field trial described in this report.

3. Techniques used for laboratory analyses should be chosen that are reliable and which produce consistent and reproducible results. Thought needs to be given to choosing appropriate techniques prior to the start of trials.

4. A statistically coherent sampling programme should be designed to adequately characterise material used in the laboratory tests and in the field trial before any operations commence. Ensure a large stockpile of material is available from which samples can be retrieved.

5. The interpretation of the results from the laboratory tests is necessary before a design for a field biopile is agreed.

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