TDP 4 - Slurry-Phase Bioreactor Trial

Originally published October, 2004

Executive Summary

SecondSite Property Holdings Ltd (SPH), now National Grid Property Holdings, commissioned Parsons Brinkerhoff Ltd (PB) to undertake the project management of a slurry-phase bioreactor remediation trial at a former gasworks site in the northwest of England. The trial was designed to demonstrate and further verify the effectiveness of slurry-phase bioremediation at commercial-scale. The project was funded by The Onyx Environmental Trust and SPH, and was carried out as part of the CL:AIRE programme of technology demonstration projects.

Slurry-phase bioremediation is the most intensive form of biological treatment available for the degradation of organic compounds. The bioreactor has been developed for laboratory and pilot trials to a commercial-scale test vessel. The vessel was first tested on a former gasworks in northern England. The results of that trial indicated that the technology worked at a field-scale. However, there were some issues that needed to be addressed with the material handling and production of foam, before the unit could be commercialised further. As part of this project several modifications were made to the plant, including upgrading the pump, changing the loading system and the installation of a remote monitoring system.

The purpose of this trial was to test the technology on the concentrated mixture of coal tar and fill material, as part of the main remediation works being undertaken at this site. Tar from a tar and liquor tank was mixed with contaminated soil in a 1:3 ratio to form the feedstock for the trial. Three full trials were completed. A fourth trial was started but terminated due to technical difficulties with the pump.

Despite encountering some difficulties during the trials in operating the bioreactor, the results of this work are promising. The results for Trial 2 in particular indicate significant levels of contaminant degradation, especially with respect to polycyclic aromatic hydrocarbons (PAH). Lighter end PAHs were degraded by up to 95%. However, the most promising results were associated with the high molecular weight PAHs such as benzo(a)pyrene, which was reduced by 68%. These results indicate how successful slurry-phase bioremediation can be in treating such contaminants in a short time-frame.

Trials 1 and 3 showed similar patterns of degradation, but not to the same degree as in Trial 2. It is thought that the difficulties with recirculation of the slurry during these trials may have contributed to the lower rates of degradation. In addition, the system needs to be made more robust, to be able to cope with changes in material size and density, loading weights and water volume. At the moment, labour input at the front end is too intensive for a commercial-scale process.

The current slurry-phase bioreactor system is suitable for certain applications. These might include a treatment process for fines produced from soil washing processes and contaminated dredging (fines) or for any material contaminated with biodegradable contaminants that can be easily suspended in water.

The bioreactor.

CL:AIRE MEMBERSHIP

In order to overcome the difficulties encountered in treating the type of heterogeneous made-ground material encountered in these trials and capitalise on the scientific basis of Trial 2, there are two main options for future development:

- Complete design change
- Further improvements and upgrades to the existing bioreactor

From the time and cost assessments detailed in this report, it is apparent that even with multiple reactors (of the design used in this project) operated in tandem, the treatment volume is not high enough to be commercially viable and, due to the low batch volume, the treatment time for the average site would still be too long. However, it must be emphasised that although this technology is in its infancy, these trials prove that this treatment option is still much quicker than convention solid-phase bioremediation and treats a greater range of organic contamination more effectively.

It is recommended that development of the bioreactor now moves on to a period of redesign, using all the lessons learned from these trials. The ultimate goal must be to produce a tank or vessel that can rapidly treat the largest batch volume possible, with greatly improved loading and unloading capacity, in order to become commercially viable. Currently, thermal treatment is likely to be the only other process that would adequately deal with these materials. It is recommended that costs and options for redesign are sought from specialist process engineers, in order to assist in the decision making process.

It is considered that, despite the difficulties that were encountered, the results of this work are very positive, as they have shown that slurry-phase bioremediation can be used to degrade contaminants commonly found on gasworks sites, both to acceptable levels and rapidly. With further improvements to design, the performance should be improved further.

The Way Forward

It can be concluded, therefore, that the Landfill Directive is going to have a significant effect on the disposal of contaminated tar found on gasworks sites. On the grounds of liquidity, corrosiveness and flammability, certain types of coal tar could easily be banned. Where waste materials do not strictly meet those categories, they will no longer be able to be landfilled by mixing with other materials. Most coal tar contaminated waste will be classed as hazardous and subject to greatly increased costs, including increased distance to the nearest available landfill site.

Remediation treatments will therefore need to be developed to reduce contaminant concentrations such that the material can be used on-site as engineering fill or sent for disposal as a non-hazardous waste.

It is considered that the work described in this report has shown that slurry-phase bioremediation can be used to degrade contaminants commonly found on gasworks sites to acceptable levels. With further improvements to design, the performance may improve further.

The current system should not be disregarded as a failed or an unsuitable system, it would act as a highly effective treatment process for contaminated silts, clays and fines from dredging. A suitable process could be of a great benefit to specific remediation projects encountering these wastes. In addition to this the current design should be tested coupled to a soil washing process to treat fines contaminated with hydrocarbons.

It is recommended that for the purpose employed during this project, the development of the bioreactor now moves on to a period of redesign, using the lessons learned in these trials. The ultimate goal must be to produce a vessel that can treat the largest volume possible per batch, in order to become commercially viable. It is also recommended that costs and options for redesign are sought from specialist process engineers, in order to assist in the decision making process.

It would envisage that any such continuing work would take the form of a joint industry project, where expertise from the whole range of specialist areas would be brought together to work in partnership in a follow-on CL:AIRE project.

To view the full report (CL:AIRE Member accounts only), log in to www.claire.co.uk and visit the Publications Library.

Originally published October, 2004