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research bulletin

CL:AIRE research bulletins describe specific, practical aspects of research which have direct application to the characterisation, monitoring or remediation of contaminated soil or groundwater. This bulletin discusses future needs for monitored natural attenuation research in the UK.

Project SIReN: Future Research Needs

1. INTRODUCTION

This is the third bulletin for the Site for Innovative Research into Monitored Natural Attenuation (SIReN). Site Bulletin (SB2) gave an introduction to the site and the SIReN Project in general terms and Research Bulletin (RB3) provided details of the research projects undertaken at the site to demonstrate the technical feasibility of Monitored Natural Attenuation (MNA). This bulletin discusses future needs for MNA research in the UK.

2. MONITORED NATURAL ATTENUATION

Several natural processes attenuate organic contaminants in the environment including:

- Biodegradation;
- Chemical degradation;
- Sorption;
- Immobilisation; and
- Dilution.

Under the right circumstances, monitoring natural attenuation processes and modelling their long-term performance can prove an effective means of risk management either as a stand-alone alternative to engineered remediation or as part of an integrated strategy where engineering techniques are used to bring about source reduction and MNA is used as a polishing step.

By harnessing these processes, which occur naturally at contaminated sites, it is possible to mitigate the potential environmental and human health risks associated with soil and groundwater contamination.

3. MNA: THE UK SITUATION

MNA has considerable potential to sustainably treat contamination *in situ*, decreasing the amount of material requiring *ex situ* treatment or disposal to landfill. Given the technical difficulties and costs inherent in many site remediation projects, MNA can provide a cost-effective risk management tool which may, on occasion, be the only technically feasible option (e.g. where the contamination is too deep for *ex situ* treatment to be viable or the stratigraphy and hydrogeology too complex to deliver *in situ* treatments uniformly to the contamination). As a result MNA has been formally recognised by the Environment Agency and other regulators as a sound approach for the remediation of appropriate sites (EA R&D Publication 95).

Assessment and monitoring of natural attenuation processes are well documented for some circumstances. For example, shallow groundwater contaminated by benzene, toluene, ethylbenzene and xylenes (BTEX) and chlorinated aliphatic compounds in unconsolidated geology in North America and the Netherlands.

However, the slow development of MNA in the UK has been compounded by the limited experience of MNA in made ground and dual porosity aquifers typical of UK conditions. This has led to low confidence in the potential for natural attenuation amongst some stakeholders and the common misconception that MNA is a "do nothing" approach (BBSRC, 1999; DETR, 2001).

The SIReN projects were initiated in 2000, to improve the understanding of and develop confidence in the application of MNA under UK hydrogeological conditions. Whilst the results demonstrate that natural attenuation of the contamination at this particular site is occurring (CL:AIRE Site Bulletin 2), further research is required to assist with the wider uptake of MNA within the UK.

4. MNA: BENEFITS AND APPLICATIONS

The advantages of MNA are broad and address the issues of economics, sustainability and, in certain cases, the inadequacies of alternative measures to deal sufficiently well with the contamination issue, e.g. desorption-limited kinetics may lead to many decades of an applied pump and treat system to significantly reduce a contamination problem. Cost reduction is the most obvious advantage; although initial site investigation costs may increase significantly (due the requirement for greater understanding of the fate and behaviour of a plume undergoing natural attenuation), the remediation engineering costs will be reduced and may even be eliminated.

In the complex heterogeneous hydrogeological conditions typical of much of the UK (e.g. dual porosity fractured aquifers, made ground etc), aggressive *in situ* engineered remediation of the whole plume is unlikely to be successful (due to poor mixing) and may even make matters worse (by spreading the contamination). In many cases, MNA may be the only technically feasible option.

5. MNA: CURRENT AND FUTURE UK LEGISLATION

The existing UK regulatory framework recognises MNA as an acceptable risk management tool provided it can be demonstrated to be protective of receptors at risk. Indeed, to encourage the application of MNA as a remedial technology, the Environment Agency has published R&D Publication 95. R&D95 provides technical guidance for demonstrating MNA that specifically considers MNA in hydrogeological conditions encountered in the UK together with a range of common pollutants. The R&D95 guidance provides:

- *Stakeholders* with a clear framework to assist in the design, evaluation and implementation of MNA strategies;
- *Regulators* with guidance on the amount and quality of data that are required to verify that MNA is effective; and
- *Third parties* with information that it is hoped will increase awareness and confidence in natural attenuation.

Over the past five years the application of MNA to the remediation of contaminated sites has become increasingly accepted, in principle, in England

and Wales. This has been assisted by high profile research efforts such as SIReN and by the position of the Environment Agency in their technical guidance. However, there is considerable scope for the increased usage of MNA as part of a risk management strategy at contaminated sites.

In the future the Water Framework Directive (WFD) and daughter Groundwater Directive (GWD) will drive much of our surface and groundwater regulation. The WFD and GWD require assessment and management of groundwater resources both at a local scale and a catchment area scale. They require, in particular, that deterioration in the quality of groundwater bodies must be prevented. Increasingly, emphasis will be placed on the numerous, smaller, diffuse sources which contribute to the overall quality deterioration, as opposed to point industrial sources. The real challenge of managing such diffuse pollution is to effect environmental improvements across whole catchment areas. Although changes in land management and practices may provide the programme of measures needed to ensure that future pollution does not occur, the remediation of pollutants already in the ground and groundwater may rely heavily, if not totally, on the natural attenuation processes. MNA will be needed not only to address point sources of industrial pollution but will also be relied on for management of diffuse pollution (e.g. from agriculture).

6. MNA: THE FUTURE

The Environment Agency supports the use of MNA on sites where a clear and strong case, based on comprehensive site characterisation, has been devised. Allowances can and are made for plume expansion beyond the immediate site boundaries providing that the protection of any receptors can be assured. However, despite the information and guidance available (see section above) it appears that confidence in MNA as a risk management tool is still limited. There are several reasons behind the limited uptake including:

- The potential length of monitoring time-frames and eventual closure compared with the normal time-frames for development and redevelopment of land;
- Difficulties associated with off-site monitoring (access, third party involvement, public perception);
- Uncertainty over the long-term sustainability of MNA at a particular site (e.g. electron acceptor sufficiency, changes in groundwater pumping regimes in the vicinity of a site);
- Perceived difficulties of using MNA in site divestments (e.g. time-frame, liability transfer, uncertainty over robustness); and
- Perception (some stakeholders do not view monitoring as doing but as problem avoidance).

Research to date on MNA has mainly focused on strategies developed for MNA of single plumes arising from single sources. Its application under such circumstances is quite well understood for contaminants such as petroleum hydrocarbons and chlorinated aliphatic hydrocarbon solvents. Strategies developed for these circumstances may require significant modification when dealing with large complex sites with multiple sources and multiple co-mingled plumes.

So how do we develop a defensible strategy for the application of MNA especially at more complex sites?

It is clear that there is a definite need for more research in certain areas to demonstrate the technical feasibility of MNA to the wider community. In particular, further research is required in the following areas:

- Understanding the effect of complex subsurface geology including fractured and fissured rock systems;
- MNA in made ground;
- Interactions between co-contaminants, effect of a mixture on the degradation rates of individual components due to preferential degradation, toxicity, effects of metabolites etc;
- MNA in low contaminant concentration systems e.g. diffuse sources of dilute contamination, where attenuation process may be dominated by physical processes;
- Biodegradation of sorbed phase organics;
- Predicting long-term sustainability of MNA (e.g. electron acceptor sufficiency);
- Vadose zone natural attenuation (e.g. vapours);
- Low cost and easier monitoring techniques;
- Strategies for mega-sites (multiple sources and multiple plumes); and
- Reporting of case histories to communicate the lessons learnt (e.g. EURODEMO).

New approaches are required to support economic application of MNA under these complex conditions.

Increasingly 'emerging' anthropogenic contaminants (e.g. pharmaceuticals) and natural microbial contaminants (e.g. BSE prion), have been recognised within 'pristine' environments (i.e. environments where these are not historically expected as contaminants). Research on these contaminants is also required in many areas including their fate and transport through the environment and the possible effectiveness of natural attenuation.

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SIReN is a national initiative for research into MNA, specifically under UK conditions. It is a joint initiative between Shell Global Solutions International, the Environment Agency for England and Wales (EA), CL:AIRE and AEA Technology. Administration of the SIReN project was funded by Biffaward Landfill Tax Credit Scheme with third party funding from the Energy Institute.

The SIReN site itself offers an excellent opportunity for large and small scale co-ordinated research into MNA under UK conditions in drift and sandstone and the SIReN team welcome research proposals on themes covered by the site research strategy.

For further information and contact details please visit the SIReN website at www.claire.co.uk/siren.php