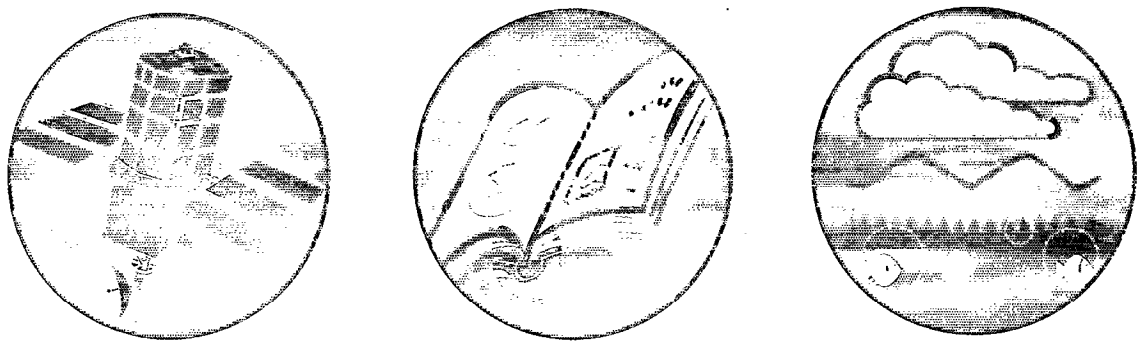
Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Groundwater



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Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Groundwater

R&D Project Record P2/134/01

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Statement of use
This document provides background information and data sources on a review of current knowledge on natural attenuation of two common organic pollutants in groundwater systems: petroleum hydrocarbons and chlorinated solvents.

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1. INTRODUCTION

The formal Project Record of an R&D project is intended to form an archive of all significant information obtained during the course of the project and not included in the Technical Report. In this case, the majority of data gathered was suitable for use, and therefore this Project Record has been limited to a summary of the references consulted, the case study reports which have been examined and the contacts made.

2. REFERENCES CONSULTED

A full list of references quoted within the Technical Report is provided as part of the report itself. The following list includes those references which have been consulted in this study, but which have not been directly quoted in the Technical Report.

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- Various Internet pages.

3. REPORTS OF CASE STUDIES

Table 3.1 lists references describing case studies in which the potential for the natural attenuation of contaminants has been assessed.

A summary of the aquifers and contaminants studied is presented as Table 3.2. A similar table is presented in

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35	Martin, M and T E Imbrigiotta (1994). "Contamination of Groundwater with Trichloroethylene at the Building 24 Site...". In *Proc. Symposium on Natural Attenuation of Groundwater*, US EPA ORD Publication EPA/600/R-94/162. September 1994, pp109-115.

Table 3.2. Summary of the aquifers and contaminants studied.

Reference	Name of Site	Country	Main Contaminant	Concentration at Source	CoMetabolites	Plume Extent	Geology	Thickness of Aquifer
1	Borden	Canada	MTBE	270 mg/l	BTEX (19 mg/l)		Sand	Borden - referenced elsewhere
2	Borden	Canada	BTEX	19 mg/l	MTBE (270 mg/l)		Sand	Borden - referenced elsewhere
3	Borden	Canada	Coal Tar Creosote				Sand	Borden - referenced elsewhere
4	Columbus AFB	US	Residual jet fuel (synthetic mix of decane, naphthalene, BTEp-xylene)				Heterogeneous (referenced elsewhere?)	
5	Various	Holland						
6	Neckar Valley	Germany	BTEX	25 mg/l	on gasworks site	250m, with two centres	Fluvial gravel with sand and silt lenses, overlain by 1-4m of clay and silt	about 4 m
7	Unknown	US	PCE and TCE					Shallow groundwater
8	TAN, INEEL	US	TCE		other contaminants present include PCE, DCE, unspecified organics, inorganics and radionuclides#	2740m	complex layering of fractured basalt flows and sedimentary interbeds	61m to 91m (sloping base). Unconfined (locally confined), depth to groundwater approx. 64m.
9	Cedar Rapids Landfill	US	TCE		landfill taking solid & liquid wastes including solvents, paint sludge and general industrial refuse	approx 30m vertically before horizontal spreading	6m Alluvial sediment over 30m 'dense and lithographic carbonates' over Silurian dolomite ranging from 'extremely fossiliferous and porous to dense'.	Horizontal flow unit (Silurian) >110m thick
10	Unknown	Canada?	EDC (1,2-DCA)	up to 4050 mg/l (DNAPL source)		~400m	3-6m silty sand and wood waste overlying silt overlying sand and gravel aquifer	5-9m
11	SE Pennsylvania	US	TCE, 1,1-TCA and PCE	CAH total 100 mg/l			14-32m sands and silts overlying recrystallised fine grained dolomite (highly irregular contact)	
12	Worley Mills, NM	US	Carbon Tetrachloride	plume moved downgradient before detection	BTEX & MTBE, and nitrate		fine to coarse grained Alluvium, unconfined	Water table at 9m
13	RCRA Subtitle C landfill	US	Methylene Chloride, PCE & TCE, ketones & aromatic VOCs	MC>640 mg/l	Acetic acid produced through MC breakdown, toluene		Sand & gravel pit, coarse glacial outwash deposits underlain by interbedded silts and fine sands	
14	Landfill	US	TCE	9.3 mg/l	landfill received paints and fuel/solvent saturated soil	400m	clayey silt, silty sand and sandy clay	sandy layer about 3m thick at about 10m depth showing referential flow
15	Former Chemical Plant (Superfund site)	US	1,2-DCA and Chloroform	up to 22 mg/l 1,2-DCA	Possibly methanol, methyl formate, dimethyl ether, isopropanol, formate, acetone and acetic acid	about 320m	interbedded alluvial silty gravelly sand	12-14m, unconfined
16	Site 1, Naval Air Station, Fallon, NA	US	PCE, TCE	PCE 0.26 mg/l, TCE 0.38 mg/l up to 3.4 mg/l cis-DCE measured max, but presumably includes degradation products	PRO & DRO	280m	Sandy aquifer	6m unconfined, water table at about 2.5m
17	Site 14, Naval Air Station, Fallon, NA	US	1,2-DCA	1.4 mg/l	PRO & DRO	95m	Sandy aquifer	6m unconfined, water table at about 2.5m
18	SE New Mexico	US	PCE	0.037 mg/l	BTEX		sand and gravel aquifer overlain by 2-3m clay with some sand and gravel layers	water table at about 3m
19	Arizona	US	PCE	150mg/l PCE, with very little TCE found near source	BTEX		60m sand, silty sand and clay overlying 60m gravel and sandy gravel aquifer	water table at 30m, 60m thick aquifer 60-120m
20	Various, SW	US	PCE, TCE			several km	alluvial and lacustrine basin fill	
21	Murdock machine & Engineering Co., Texas	US	TCE & 1,1,1,-TCA	36 mg/l TCE, 113 mg/l TCA		400m	Alluvium - sands and gravels overlain by clayey material and containing clayey lenses	total thickness of Alluvium 15-42 feet, sands and gravels absent or thin in some areas
22	Pease AFB, NH	US	BTEX and Naphthalene			various (60 plumes)		

Table 3.2. S

Reference	Permeability	Distance to Receptor	GW velocity	Success Rate	Comments
1			0.09 m/d	200 ug/l in 6 years	Rate Constant = 0.0012 /d
2			0.09 m/d	5 ug/l in 4 years	
3			0.09 m/d	Phenol removed in < 2 yrs, m-xylene increased to about 2 yrs, then decreased to 1357 days, dibenzofuran plume stationary to 1357 days (replenished from source), naphthalene increasing up to 1357 days (poor candidate for NA)	
4			0.5 m/d	Hydrocarbon plume stabilistaion within a few weeks at about 15m, mono aromatics at around 12m, naphthalene *initially stable then extended as conditions changed from aerobic to anaerobic. Redox zones not delineated* using dissolved H2.	
5					
6	average K 10^{-5} m/s, but highly variable		2.5 m/d		
7				Model predictions more VC degraded than formed after 15 yrs.	TCE anaerobic half life of 4 yrs, cis-1,2-DCE of 9 yrs.
8				evidence for anaerobic reductive dechlorination of TCE, and aerobic attenuation of TCE and DCE. Aerobic mechanism not determined.	
9	Variable. Includes a mudstone band beneath the plume's vertical movement		0.05 ft/day to 1.0 ft/day approx (not clear whether retarded/unretarded/calibration example)	recognised lines of evidence strongly demonstrate TCE degradation	Check interpretation, particularly wrt TCE and DCE occurrence downgradient. Rate constants determined as TCE 0.33-0.83 /yr, DCE 0.62-0.96 /yr and VC 0.46-1.27 /yr.
10	1.6×10^{-2} m/s	2000-3400 m	hydr. grad. of 0.0003	evidence for DCA degradation, but VC accumulation	other remedial methods: soil vapour extraction, direct pumping, gw removal with air stripping, and air injection curtain, sequentially turned off.
11	fracture flow, 1.5 m/d		0.09 m/d, gradient of 0.008 (probably enhanced by quarry dewatering)		oxic environment. Needs another look - is it what it says?
12		120m	hydraulic gradient of 0.002	non detection within 6 years of initial monitoring. CT plume stable until petrol leak provided carbon source for degradation. Away from petrol plume, nitrate plume allowed mineralisation of CT to CO2.	CT half life of 12 years, decay coefficient of 0.058 /yr. Fortuitous combination of events resulted in NA as only (and successful) cleanup *method.*
13	coarse deposits $2x10^{-4}$ m/s, sands and silts $1x10^{-6}$ m/s			Complete degradation of PCE through to CO2 because of sequential redox zones and cometabolites. Degradation of Methylene chloride	
14			0.13 ft/d (47 ft/yr) Hydraulic gradient 0.0094	Plume shown to be at steady state with geochemical evidence for biodegradation VC decreasing rapidly at 1mg/l O_2 boundary.	Multiple possible sources dealt with and modelled
15			110 m/yr	100 fold decrease in chloroform concentration in 125m compared to a 3 fold decrease of chloride as a conservative tracer (also produced?) and DCA. Microcosm studies show DCA aerobic degradation 97% of 10 mg/l in 6 days.	methanogens reported sensitive to chloroform (reference), so DCA doesn't completely degrade anaerobically, some degrades aerobically
16	51.5 ft/d		hydraulic gradient of 0.001	PCE and TCE plume extending beyond DCE and VC area suggests reductive dechlorination not sufficient to contain contamination	background DO < 2mg/l, but high nitrate (up to 40mg/l) and sulphate (to 10,000mg/l). NA p166 - high nitrate and sulphate may inhibit reductive dehalogenation at high concentrations through competition.
17	25-37 ft/d		hydraulic gradient of 0.001	DCA plume stable or shrinking, and ethane & ethene non-toxic degradation products	background DO < 2mg/l, but high nitrate (up to 40mg/l) and sulphate (to 10,000mg/l)
18					PCE, TCE and some cis-DEC detected within a BTEX plume with no source identified. PCE detected upgradient, with no TCE, therefore PCE *degradation assumed with BTEX as cometabolite (no PCE degradation* outside BTEX plume)
19					No TCE detected except arounf BTEX plume (PCE degradation inferred since no TCE source found)
20	varies			unsuccessful, because aquifer has oxic groundwater	more detail available in the paper & references, but this is the main point
21	varies (point of paper)			plume stabilised with total VOC mass reduced 66% in 3 years (some build up of degradation products?)	AFCEE protocol yielded 'limited' evidence of NA since groundwater samples were primarily from higher k areas and contamination was diffusing from clayey material
22					calculated expected clean-up times (but in the end, could they have come up with the same results based purely on plume size?)

Reference	Name of Site	Country	Main Contaminant	Concentration at Source	CoMetabolites	Plume Extent	Geology	Thickness of Aquifer
23	Rotterdam	Holland	1,2-DCA				complex sedimentary layering including a 4m added sand layer and sand columns for construction purposes	
24	Columbus AFB, MS	US	Benzene, naphthalene, p-xylene and dichlorobenzene	approx 160 mg/l total dissolved hydrocarbons			heterogeneous aquifer	
25	Susteren	Holland	Mineral Oil, toluene and xylene		Benzene			"Limited depth of groundwater contamination"
26	Grindsted	Denmark	18 xenobiotic compounds injected into a domestic landfill leachate plume	75-330 ug/l		30-60 m		
27	Groningen	Holland	PCE & TCE					
28	Groningen	Holland	PCE & TCE					
29	Maassluis	Holland	PCE & TCE					
30	Three sites	Holland	BTEX				Deep anaerobic aquifer (sulphate reducing).	
31	Dover AFB, Delaware	US	PCE, TCE		Petroleum hydrocarbons	2600m long and 1000m wide	fine and coarse grained sands	9 to 21 m
32	North Toronto	Canada	PCE	4.4 mg/l	methanol and acetate			
33	Hawkesbury, Ontario	Canada	PCE, TCE, TCA and DCM		volatile fatty acids and methanol			
34	St Joseph, Michigan	US	TCE	100 mg/l	waste leaching from a disposal lagoon, COD 400 mg/l			
35	Picatinny Arsenal, NJ	US	TCE	>10,000 ug/l		130,000 m^2, total mass of TCE around 970 kg. Extends 500m before discharge to receptor at which point it is about 350m wide.		

Reference	Permeability	Distance to Receptor	GW velocity	Success Rate	Comments
23				not sure, yeast added, looks ok but complicated	pump & treat used in conjunction with MNA
24			5 m/yr to >400 m/yr	Sorbtion and volatilisation shown in lab to be insignificant. After 440 days, percent remaining was benzene, 6, naphthalene, 6, p-xylene, 1 and dichlorobenzene, 13. Degradation half lives 50 to 100 days.	Testing suggests aerobic degradation.
25		In a water protection area		Nitrate and oxygen absent within the plume, and methane measured up to 18 mg/l indicating biodegradation occurring, but not quantified.	
26				Complete mass removal of toluene in reduced part of aquifer (Fe reducing onwards), partial degradation of naphthalene (all parts of aquifer) and o-xylene (less reduced parts), no benzene degradation, and insufficient data for m/p-xylene and ethylbenzene.	In situ microcosm studies and lab. batch tests showed good agreement with field results, with ISMs appropriate for compounds 'without too long lag periods', and batch tests useful for mixtures of compounds with varying lag periods and degradation rates.
27				In one area, reduction of PCE and TCE to cis-DCE and VC in reduced conditons followed by removal of DCE and VC in oxic zone.	
28				In another area, complete reductive dechlorination of PCE and TCE to VC, ethene and ethane (methanogenic & sulphate reducing conditions), but degradation of VC too slow to prevent migration to receptors.	DOC <10 mg/l suggested to indicate insufficient electron donors present naturally; proposed to add them.
29				Complete reductive dechlorination occurs	DOC 700 mg/l
30				Toluene and ethylbenzene degradation in field and microcosm studies, No benzene degradation in field or lab.	Some benzene degradation measured in microcosms, but due to low oxygen concentrations introduced accidentally. Introduction of O2 on purpose stimulated benzene degradation.
31		River approx 1800m	35 to 70 m/yr, gradient of 0.0008 to 0.0019	PCE and TCE assumed to degrade once conditions become anaerobic following breakdown of hydrocarbons. Daughter products detected inside the plume, but not far outside - assumed to degrade aerobically. Receptor concluded to be protected.	DO 4 mg/l outside plume, <1 mg/l inside. Methane 0 outside, up to 0.7 mg/l inside.
32				TCE, cis-DCE and VC found with high PCE. Downgradient only cis-DCE, VC and ethene. Other DCE isomers not found. Methan production shown.	
33				transformation products measured, but low ethene and ethane, indicating incomplete degradation.	sulphate non detectable, dissolved iron high, methane present, indicationg conditions suitable for reductive dehalogenation.
34				8-25% of TCE converted to ethene near source. 24 fold reduction in hydrocarbons downgradient, with conversion of TCE to ethene most complete where methane production highest.	Further details available in separate publications, e.g Wilson et al., pp116-119, same synposium.
35		Travel time (to brook) estimated at 2 to 5 years.	0.3-1.0 m/d	cis-DCE and VC detected, and methane in groundwater indicates methanogenic conditions. Probable DNAPL source.	

4. THIRD PARTIES CONSULTED

A number of consultants, contractors, researchers and problem holders, both within the UK and abroad have been consulted as part of this project. The following list includes all contacts made, regardless of whether or not they were able to supply relevant information for inclusion within the Technical Report. Copies of e-mails and records of telephone conversations have been included as Appendix 1. The numerous informal discussions held with parties interested in the application of MNA have not been listed below.

4.1 UK research contacts

Willie Burgess, UCL
Geoff Williams, BGS
Bob Kalin, Queens University Belfast
David Lerner, Sheffield University
Mike Rivett, Birmingham University
Kevin Jones, Lancaster University

4.2 UK industry contacts

Gordon Lethbridge, Shell Research Ltd.
Phil Morgan, ICI Technology.
Steve Rumford, Zeneca Limited
Bill Hafker, Esso
Martyn Lambson, BP

4.3 UK contractor & consultant contacts

Chris Dainton, Celtic Technologies
Nick McSuigan, Landclean
Peter Taylor, Oil Spill Response Limited

4.4 US contacts

Chris Neville, Shell
Mark Harkness, GE Corporate research & Development
Dave Ellis, DuPont (and RTDF)
Numerous contacts through Todd Rees, Golder Associates USA.

4.5 Other contacts

Huub Rijnaarts,TNO, The Netherlands.
Greg Davis, CSIRO, Australia

APPENDICES

APPENDIX 1

COPIES OF E-MAILS AND RECORDS OF TELEPHONE CONVERSATIONS

Author: Bridget Plimmer at GAUK_NOTTINGHAM
Date: 19/11/98 13:34
Priority: Normal
TO: w.burgess@ucl.ac.uk at Internet
Subject: Natural Attenuation
---------- Message Contents ----------

Dear Dr Burgess,

Golder Associates are working on a research contract for the Environment Agency for which we will be examining natural attenuation as a remediation option for groundwater contaminated with BTEX and/or chlorinated solvents.

The project is to focus on where/when natural attenuation may be applicable in the UK (hydrogeological conditions, source concentrations etc.), so we're looking for case studies in which natural attenuation has been used as a remediation technique, or, perhaps more importantly, where it has been tried and failed.

Have you (or any of your colleagues) worked on any such projects, and would you be prepared to share any data with us.

If you would like to phone for a chat, I can be reached on 0115 9456544, or you can e:mail me (bplimmer@golder.com).

Thanks for your time

Bridget Plimmer
Golder Associates (UK) Ltd
Landmere Lane
Edwalton
Nottingham
NG12 4DG

Bridget,

We've worked on a Creosote site (overlying karst limestone and thus focused on the soil zone) this was mostly microbiology and some chemistry. We've worked on the microbiology (pH, O2, nutrients, etc for growth) of extreme halophiles from contaminated sites (mostly chlorinated solvents). Last summer We starting work on a gas works site (done some chemistry and microbiology). However, to take things as far as NA used in the USA and Canada, we're having trouble convincing site owners to spend much more than spare change on site investigation at this point (to prove and validate NA). There is a good chance of two large project starting at the beginning of 1999 (one in collaboration with Golders. I'd be willing to toss in my 2-cents worth, however I'd have to get permission to release any information.

Bob

Dr. Robert M. Kalin
Director, Environmental Engineering Research Centre
School of Civil Engineering
The Queen's University of Belfast
Belfast BT7 1NN N. Ireland UK
r.kalin@qub.ac.uk http://www.qub.ac.uk
Fax +44 1232 663754
Phone +44 1232 274018 / 274363

Golder Associates

RECORD OF TELEPHONE CONVERSATION

Project/Project No. 98525316
Date 29 October 1998
Cross Reference
Company Name Sheffield Uni.
Contact Name David Lerner.

Notes

Case Studies – generally can't help, they've done quite a lot of work but want to publish in the refereed literature before giving us all their data. Mansfield Colliery is furthest along, David will send copy of paper from Redflow conference earlier this month in Colorado. Organics have attenuated, inorganics haven't. Four Ashes results are too preliminary to be useful, but NA probably won't work, David to forward paper. Won't release any later data.

Web Site / Information Exchange – intended as a list of contacts more than a data source. Can be found on Sheffield.ac.uk/~nnags (one n?). Was only set up on Monday.

Further research he'd like to see – won't say. Environmental controls on degradation rates etc.

Copy to _____ Signed _____

Dear Bridget

Thanks for the email.

Sorry, but I am afraid that I will not be very much help. I have not worked on any sites where there has been enough gw monitoring to say whether NA is, or is not occuring. I am only really aware of David Lerner's (Sheffield Univ) work where they have attempted to look in some detail at the process. I assume that you are aware of the NAGGS website they have set up. Most contam land sites I dealt with in the EA did not have the sensitivity to justify loads of GW monitoring hence could not say anything very positive on NA - many sites it was speculated too occur, but not really thought about / investigated in any detail.

I think that you best route would be via Industry, eg BG, ICI, Shell, Zeneca (via SAGTA?) etc. - they are all great fans of NA for obvious reasons!

My gut reaction is that NA certainly OK for most H/C, doubt it would be of much use for the chlorinated, although we certainly have seen some part-way degradation products at some sites/aquifers (ie DCE's vinyl chloride, a worse problem than what you start with). I doubt if there are any sites in the UK where monitoring has been carried out to show complete solvent degradation to benign products.

If I can think of anything else more helpful, I will let you know.

Mike

Dr Michael Rivett
Lecturer in Hydrogeology
School of Earth Sciences
University of Birmingham
Edgbaston
Birmingham B15 2TT, UK

Tel: +44 (0)121 414 3957
Fax: +44 (0)121 414 4942

Author: Bridget Plimmer at GAUK_NOTTINGHAM
Date: 28/10/98 12:36
Priority: Normal
TO: k.c.jones@lancaster.ac.uk at Internet
Subject: Natural Attenuation

---------- Message Contents ----------

Dear Kevin,

Golder Associates are working on a research contract for the Environment Agency for which we will be examining natural attenuation as a remediation option for groundwater contaminated with BTEX and/or chlorinated solvents.

The project is to focus on where/when natural attenuation may be applicable in the UK (hydrogeological conditions, source concentrations etc.), so we're looking for case studies in which natural attenuation has been used as a remediation technique, or, perhaps more importantly, where it has been tried and failed.

Have you (or any of your colleagues) worked on any such projects, and would you be prepared to share any data with us.

If you would like to telephone for a chat, I can be reached on 0115 9456544, or you can e:mail me (bplimmer@golder.com).

Thanks for your time.

Bridget Plimmer
Golder Associates (UK) Ltd
Landmere Lane
Edwalton
Nottingham
NG12 4DG

-reply 29 October. Not something they've worked on.

Gordon Lethbridge (Shell), Phil Morgan (CIG), DHH, BEP

9.11.98

NOBIS: Harry Vermeulen - Johan Bouwer (TNO)
ESSO: Bill Hafker
TNO: Tom Bosma, Anya Sinke. (NICOLE) Review of previous work.
FOCIL

Project Parkway Duncan. BGS. Quarry landfills. Microcosm studies were inconclusive. Julie West Adrian Lawrence. Doubts over quality. May be looked at in isolated areas in the future. Source zone difficult to identify.

Also in NICOLE - British Gas, BNFL, Zeneka, (Steve Rowford)

Debate-respirors work being done in US & Germany / Switzerland. Field & isolated population.

Shell USA - Kirk Stanley, Joe Salanito, West Hater Technology Centre, Houston. Chris Neville. Phoenix Terminal. (DD 281 544 7088

Jeremy Joseph.
Richard Swan BEA.

NOBIS Decision Making System. Protocol. (Anger) Tightly focussed on anaerobic processes.
Dutch focussed on biological effects.

RTDF chlorinated solvents training package 'Europeanised' by ICI & will incorporate Dutch learning. Bob will get people on. Good for case studies.
Philadelphia State website.

Evaluation of several hundred plume datasets to see if chlorinate solvent NA is occurring Clawrence Livermore & Oakridge. Prob. U. Follow up to hydrocarbons.

West Hater also put training guidelines together for ASTM.

20% guesstimate of number of chlorinated sites it will work for its a

Author: "Rumford Steve SP" [SMTP:Steve.Rumford@BRIXHAM.zeneca.com] at US_SEATTLE_WA
Date: 20/11/98 00:30
Priority: Normal
TO: Bridget Plimmer at GAUK_NOTTINGHAM
Subject: RE:
---------- Message Contents ----------
Dear Bridget

I am aware of one site where there is strong evidence that natural attenuation of chlorinated solvents is occurring. However the site did not need to investigate the natural attenuation in order to demonstrate to the NRA (now EA) that significant harm was not occurring. Therefore the evidence is strong but has not been investigated fully. The situation is complicated by the site no longer belonging to Zeneca. However, we do still provide advice and monitoring.

Otherwise, we have increasing evidence on one of our sites (and this is being investigated) of natural attenuation of a large plume of nitrobenzene and nitrotoluene. The evidence is showing that aerobically the nitroaromatics degrade very fast (half lifes in days), but, not unsurprisingly, that there is little DO in the plume. Anaerobic degradation is probably occuring (evidence is presently contradictory) but rates are slow. But this presumably falls outside the scope of your research contract.

Regards
Steve Rumford
Zeneca Limited
Brixham Environmental Laboratory

e-mail: steve.rumford@brixham.zeneca.com

>----------
>From: Bridget Plimmer[SMTP:BPlimmer@GOLDER.com]
>Sent: 19 November 1998 20:45
>To: Rumford Steve SP
>
>
>
> Dear Steve,
>
> Golder Associates are working on a research contract for the
> Environment Agency for which we will be examining natural attenuation
> as a remediation option for groundwater contaminated with BTEX and/or
> chlorinated solvents.
>
> The project is to focus on where/when natural attenuation may be
> applicable in the UK (hydrogeological conditions, source
> concentrations etc.), so we're looking for case studies in which
> natural attenuation has been used as a remediation technique, or,
> perhaps more importantly, where it has been tried and failed.
>
> Have you dealt with any such projects, and would you be prepared to
> share any data with us.
>
> If you would like to phone for a chat, I can be reached on 0115
> 9456544, or you can e:mail me (bplimmer@golder.com).
>
> Thanks for your time
>
> Bridget Plimmer
> Golder Associates (UK) Ltd
> Landmere Lane
> Edwalton
> Nottingham
> NG12 4DG
>

Golder Associates (UK) Ltd
Landmere Lane
Edwalton
Nottingham NG12 4DG
England
Tel: 0115 945 6544
Fax: 0115 945 6540
E-mail: nottingham@golder.com
http: //www.golder.com

Golder Associates
25 Years of Professional Consulting in the UK

Mr C Dainton
Celtic Technologies
CDT Centre
Senghenydd Road
Cardiff
CF2 4AY

Ref: 98525316.100

11 November 1998

Dear Chris

Re: Natural Attenuation Research Project

Following our telephone conversation yesterday, I write to confirm our involvement in the study of natural attenuation as a remedial technique for groundwater contaminated with chlorinated hydrocarbons and/or BTEX, on behalf of the Environment Agency.

As we discussed, you will already be aware of the aims of the research. We are currently looking for details of sites where natural attenuation has been used as a remediation option (including those sites where it has been used alongside other technologies), or perhaps more importantly where natural attenuation has been tried and failed (or has not been proven).

Have you been involved with any such sites for which you would be prepared to share details with us? Obviously, site anonymity could be preserved if you or your clients wished.

Since part of the project is to highlight those aspects requiring further research so that the Environment Agency may target future funding, perhaps you might also like to suggest areas in which your work on natural attenuation projects would benefit from additional information.

If you can assist in any way, please feel free to phone me for a chat, or perhaps it would be more beneficial for me to drop in to your offices.

Thank you for your time.

Yours sincerely
Golder Associates (UK) Ltd

Bridget Plimmer
Hydrogeologist

BP/lf

Author: "pmtaylor@osrl.co.uk" [SMTP:pmtaylor@osrl.co.uk] at US_SEATTLE_WA
Date: 16/12/98 03:04
Priority: Normal
TO: Bridget Plimmer at GAUK_NOTTINGHAM
Subject: NA

---------- Message Contents ----------

Bridget:

I don't think we can be of any help. Our experience in primarily in the field of marine oil spills, though we have had occasional involvement with oil spills to land and freshwaters. Our input to these latter types spills has been limited to the removal of gross pollution, either pooled on the surface of the land or recovered from the surface of water courses. On rare instances we have dug shallow interception trenches.

The specific problems of dealing with contaminated soil or groundwaters is generally outside of our expertise. For your interest, we are looking at ways of including basic advice on this subject in our various training courses. This will probably involve assistance from some outside organisation (can you help us here!). By coincidence, I have a colleague meeting with a gentleman from Shell Research today to discuss this very subject.

Sorry I cannot give you anything very useful.

Regards,

Peter

Oil Spill Response Ltd.

Golder Associates

RECORD OF TELEPHONE CONVERSATION

Project/Project No. 9252
Date
Cross Reference
Company Name
Contact Name

Notes

Huub Rijnaarts at TNO –

they are working on a similar project, and although they're not keen to just release data, they would be happy to consider some sort of cooperative effort. They may be able to release limited data, but so far the work has been written up as internal reports and the site owners may get jumpy about publication. They'd like some influence over what we write.

TNO have been studying:

12 chlorinated solvent sites for ~ 2yrs. A number show NA to be feasible, but others show plume will expand to a sensitive receptor before removal.

5 BTEX sites. Deep anaerobic conditions in Holland show degradation of TEX but benzene difficult to degrade.

Some Lindane, cyclohexane etc. sites showing mixed results.

Said I'd discuss with DHH and perhaps mention at ssp meeting, and let him know by e-mail next week

Copy to

Signed

Author: "Greg Davis" [SMTP:Greg.Davis@per.clw.csiro.au] at US_SEATTLE_WA
Date: 18/12/98 04:57
Priority: Normal
TO: Bridget Plimmer at GAUK_NOTTINGHAM
Subject: Re: Natural Attenuation
---------- Message Contents ----------

Bridget,

You are no doubt aware of the two documents from the US on NA of BTEX and Chlorinated solvents in groundwater by Wiedemeier et al (can probably be sourced through US EPA or DoD). Also, locally in the UK Sheffield University and others (David Lerner) have set up the NNAGS (Network on Natural Attenuation in Groundwater and Soil) web site and newsletter at: http://www/shef.ac.uk/~nnags

In Australia, NA is used to varying degrees, mostly without detailed assessment, but certainly not always. For the shallow sand aquifer in Perth, WA, we have run two research projects which have shown limited NA, ie (i) benzene to persist in sulphate-reducing groundwater conditions where gasoline leaked from a UST, generating plumes over 400 m long. At this site toluene and other gasoline components degrade preferentially while benzene is most persistent - I realise this is a little at odds with some lab/field research which shows some degradation of benzene under sulphate-reducing conditions.:
(ii) TCE to not degrade or sorb in anaerobic groundwater, with a plume over)0 m long. Other organic carbon is low, so little degradation may be expected. 800
Regulators and industry are starting to converge on some strategies for NA, I guess. We are running a conference here in March 1999, where we hope to address this issue a little more amongst other issues - you may be interested - see the web site:
http://www.clw.csiro.au/CGS/conferences/

Also, we have a number of publications in this area, most are listed at our web page at:
Group Web page: http://www.clw.csiro.au/research/groundwater/remediation/

I hope some of this helps.
Greg Davis

At 10:07 16/12/98 -0800, you wrote:
> Dear Greg,
>
> Golder Associates in the UK are working on a research contract for the UK Environment Agency for which we will be examining natural attenuation as a remediation option for groundwater contaminated with BTEX and/or chlorinated solvents.
>
> The project is to focus on where/when natural attenuation may be applicable in the UK (hydrogeological conditions, source concentrations etc.), and will compare current knowledge and use of natural attenuation abroad with that over here.
>
> I know it's a large subject, but we would be interested in any comments you can make regarding research and practice in Australia. Is natural attenuation commonly applied, and if not, why not? What conditions are you finding to be most favourable. Have you any information on sites where natural attenuation has been found not to work etc.
>
> If you or any of your colleagues can help, or suggest others that I may be able to contact, we would be most grateful.
>
> Regards
>
> Bridget Plimmer
>
> Hydrogeologist
> Golder Associates (UK) Ltd.
> Landmere Lane
> Edwalton
> Nottingham
> NG12 4DG
> England