IN-SITU BIOSPARGING OF PENTACHLOROPHENOL (PCP) CONTAMINATED GROUNDWATER

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ABSTRACT:`Seven biosparging wells were installed near the property boundary at a wood-treating site to eliminate or minimize the migration of dissolved-phase pentachlorophenol (PCP) in groundwater to the adjacent property. Sparging wells were spaced about 40 to 60 feet radially from each other with expected air or oxygenated radius of influence of 20 to 40 feet. PCP concentration range of 0.21 and 1.20 mg/L was detected in water samples collected from temporary wells installed to evaluate the design and placement of biosparging wells. Exogenous, commercially available chlorophenol degrading microbial cultures, nitrogen, and other required nutrient sources were injected into the sparging system to enhance biodegredation of PCP on quarterly basis for a period of three and half years. PCP concentrations for the most contaminated well for 2001, 2002, 2003, and the first and second quarter of 2004 were 3.30 mg/L, 3.60 mg/L, 3.05 mg/L and 1.60 mg/L respectively. The second most contaminated well showed PCP levels of 0.90 mL, 1.16 mg/L, .688 mg/L, and .213 mg/L for the same time period respectively. No consistent correlation between tetrachlrophenol (PCP by-product) increase and PCP reduction was observed for 2002-2004 sampling periods. PCP acclimated bacteria counts were 9,500, 10,700, and 46,000 colonies per mL for the three most contaminated wells indicating a good biosparging environment. No migration of PCP to adjacent property's groundwater was detected.

INTRODUCTION

Contamination of groundwater by organic wood treating chemicals such as pentachlorophenol (PCP) is one of the most difficult tasks facing environmental scientists for two reasons. First this chemical is highly toxic and causes a major concern wherever it has been detected in groundwater. Second it is very stable and like most chlorinated solvents, hard to break down. Application of any successful new technology could be of great of value to the wood treating industry.

Bioparging is a promising technology for the treatment of groundwater contaminated by dissolved volatile organic compounds and chlorinated solvents. It involves the injection of clean air under pressure into saturated zones. The injected air displaces water and creates air filled porosity in the saturated soils, volatilizes and removes dissolved and adsorbed chemicals and transfers oxygen into the groundwater. As a result both physical removal and aerobic biodegradation of contaminants in groundwater and saturated soil are enhanced (Bass and Brown 1997). This technology, when augmented by nutrient and proper microbial systems, has been demonstrated to reduce costs of the remediation of contaminated sites and manage the migration of contaminants in the subsurface (Maheux and McKee 1997). It offers a means of remediating soil

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and groundwater without the need for active groundwater pumping and in some cases biosparging appears to have produced significant and permanent reduction in groundwater contaminant concentrations (Bass and Brown 1997; Tang et al. 1999).

The objective of the biosparging system was to eliminate or minimize offsite migration of dissolved phase pentachlorophenol (PCP) in groundwater to the adjacent property. The biosparging system served as an aerated treatment barrier, or "curtain," whereby microorganisms degrade or consume PCP in the groundwater as it flowed toward the property boundary.

MATERIALS AND METHODS

Seven biosparging wells were installed in the area of concern. These wells were located along a transect about 60 feet south of and parallel to the property boundary, along a line perpendicular to the general groundwater flow direction. The biosparging wells were spaced at approximately 60-foot intervals and form a "curtain" upgradient from the property boundary. Biosparging wells consist of 2-inch, schedule 40 PVC with a 5-foot slotted screen section at the bottom of the well (positioned within the base of the saturated zone). This design allows for remediation of the full thickness of the saturated zone, as the air migrates upward through the zone toward ground surface. The biosparging well depths ranged from 23.0 to 29.0 feet below ground surface(bgs).

The blower was a regenerative type that supplied up to 105 standard cubic feet per minute (scfm) of air at 15 pounds per square inch (psi). The blower unit mounted on a concrete pad was housed in a 4-foot by 4-foot prefabricated metal building and was directly coupled to an electric motor and controlled by a magnetic starter and a rotary on-off switch. It was facilitated with a pressure and a temperature gauge mounted on the blower discharge. The blower was connected to the seven biosparging wells via underground 2-inch PVC piping. The wells were flush mounted (i.e., below surface) and equipped with ball valves and pressure gauges.

Exogenous, commercially available bacteria that are known to degrade chlorophenol, were injected into the sparging wells on bimonthly intervals until 2002. Nitrogen and other required nutrient sources were also added to the system to enhance biodegradation of PCP. Samples were collected on quarterly intervals for chemical and biological monitoring of this remediation project. All analysis were conducted according to EPA and Standard Method for the examination of water and wastewater.

RESULTS AND DISCUSSION

The pentachlorphenol concentration results from monitoring wells are summarized in Table 1. The concentration given at each year is an average of four samples taken quarterly. No samples were taken from MW# 44 due to dryness of this well during 2003-2004 period. The biggest impact of biosparging was seen in MW# 51 in which the concentration of PCP decreased by 50% from 3.30 to 1.650. The same results were also observed for MW# 14 (the up gradient monitoring well). A significant increase in PCP concentration in MW# 52

occurred in the 2003 and 2004 sampling periods. This increase could be attributed to contaminant moving on that direction or some other unexplained factors. No PCP has been detected in any down gradient wells since 2003. Only MW# 17 showed insignificant amounts of PCP in 2001 and 2002 period. Bacterial population remained consistent for both intermediate wells(Table 2). Down gradient wells ranged from as high as 25,000 colonies/mL to no colonies during this period (Table 2).

Table 1. Pentachlorphenol concentrations (mg/L) in monitoring wells during four years of biosparging.

Up gradient wells	**2001**	**2002**	**2003**	**2004****
MW# 14	.90	1.16	.668	.213
MW# 44	.078	.185	------	------
Intermediate wells				
MW# 51	3.50	3.40	3.05	1.650
MW# 52	.026	.013	0.350	.550
Down gradient				
MW# 17	.042	.015	ND	ND*
MW#41	ND	ND	ND	ND
MW# 42	ND	ND	ND	ND
MW# 43	ND	ND	ND	ND

* ND: none-detect at 1ug/L
** 2004 represents only 1st and 2nd quarterly sampling.

Table 2. Bacterial population in colony/mL during 2001-2004 biosparging period.

Up gradient well	**2001**	**2002**	**2003**	**2004**
# 14	3400	3500	4800	10700
# 44	4800	700	------	-------
Intermediate well				
# 51	2340	4250	2500	9500
# 52	51900	4600	7300	46000
Down gradient				
# 17	25000	1000	81000	3100
# 41	NC	NC	NC	NC*
# 42	NC	NC	NC	800
# 43	3900	3900	1700	3850

* NC: not counted due to very low number
** 2004: Represents only 1st and 2nd quarterly sampling.

To measure the amount or presence of by- products from this sparging experiment, tetrachlorophenol was selected to be monitored for three of the most contaminated wells for 2002 through 2004 (Table 3). No conclusive evidence or correlation between PCP reduction and increase in by-products was observed.

Table 3. Tetrachlorophenol concentration (mg/mL) during 2002-2004 monitoring.

	2002	**2003**	**2004**
Well# 14	.131	.072	.045
Well# 51	.1811	.251	0.0190
Well# 52	.0018	.048	.097

CONCLUSION

Data from three and a half years evaluation period indicated a significant and consistent reduction of PCP in most of the contaminated intermediate zone and the up-gradient zone of biosparging system. This reduction has been gradual but consistent. The increase of PCP in MW# 52 is troubling and hard to explain. However, since no PCP has been detected in down gradient wells since 2003, the main objective which is preventing offsite migration of dissolved phase PCP in groundwater to adjacent property continues to be accomplished.

Future plan: Addition of innocuous sources, such as molasses, to the biosparging wells in small quantities could help increase microbial populations in groundwater and degrade PCP at faster rates.

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REFERENCES

Bass, D.H., and R.H. Brown. 1997. Performance of air sparging systems: A review of case studies. In: In-situ and on-site bioremediation. Alleman and Leeson (eds). Battelle Press, Columbus, OH, pp. 117-122

Maheux, P.J., and R.C.E. McKee. 1997. An in situ air sparging method: Contiguous sand columns. In: In-situ and on-site bioremediation. Allemand and Leeson (eds). Battelle Press, Columbus, OH, pp. 221-232.

Tang, J., G.R. Walter, and M.W. Kuhn. 1999. Field pilot study of trench air sparging for remediation of petroleum hydrocarbons in groundwater. In: In-situ bioremediaitonof petroleum hydrocarbon and other organic compounds. Alleman and Leeson (eds). Battell Press, Columbus, OH, pp. 59-64.