CASE STUDY: IN-SITU REMEDIATION OF PCB CONTAMINATED SOILS NEW JERSEY, USA

EXECUTIVE SUMMARY

At the request of a New Jersey based company Nordevco Associates Ltd. undertook a bench-scale PCB biodegradation treatability study in February of 1993. The study was completed in May of that year and the results were submitted to the New Jersey Department of Environmental Protection and Energy (NJDEPE) for review. As a result of the data submitted, Nordevco Associates Ltd. was granted permission by the Department to apply its technology to a PCB Aroclor 1248 contaminated site in central New Jersey. The PCB impacted area (approximately 400 m^2 to a depth of 1 meter) sits in a corner of a property that once housed a plant for manufactured gas.

Originally scheduled for July 6, 1993 the first application of Nordevco's products/technology was delayed (due to contract negotiations between the supervising consultant, Metcalf & Eddy, and the client) until September 17, 1993. Bacterial products were applied on a weekly basis until December 7, 1993. It was felt that due to the onset of colder weather conditions, further additions of product would be ineffective.

The 1994 additions season, like the 1993 one, was delayed by similar contract negotiations. Therefore, the first application of bacterial products did not take place until June 23, 1994.

Initial analysis of the soils used in the treatability study (removed from the site and supplied by the supervising consulting firm Metcalf & Eddy) indicated the presence of Aroclor 1248 and small quantities of Polycyclic Aromatic Hydrocarbons (PAHs). In designing the full-scale site remediation plan, Nordevco design staff assumed that due to the past nature of the site, greater concentrations and varieties of PAHs would be found in the soils. This was later confirmed by Metcalf & Eddy during soils testing to monitor the rates of PCB biodegradation.
The results given in this report deal with the degradation of PAHs between September 16, 1993 and July 25, 1994 (bearing in mind that after December 1993 the treatment was solely a passive one with no further microbial products or nutrients being added). After that period the supervising consultant decided that no further analyses for PAHs should be carried out.
The results for PCBs, both total specific Aroclor and PCB-congeners, was carried out for the period September 16, 1993 to December 7, 1993

THE TECHNOLOGY

Nordevco's BactiDomus® Technology was developed by a diversified group of research scientists working together at Universities in Belgium and France. Their goal was to create a mechanism with the flexibility to delivery biological solutions to a range of environmental issues more effectively and efficiently

The foundation for the success of the BactiDomus® Technology was the development team's clear understands that for any carrier material to be successful it had to meet specific underlying needs of the organisms:

- Regardless of the organisms used, they would be cultured in a sterile laboratory and would require time to acclimate to the environment they were activated in.
- Microorganisms, like humans, do not exist or thrive in isolation of each other but rather rely on others for stimulation and competition;
- Organisms prefer to grow and live in colonies or flocs and prefer to attach to something to anchor these colonies;
- Individual species of microorganisms do not work in isolation to break down organic compounds. To successfully break down any organic completely to CO2 and H20, a variety of different organisms are required;

The result of that work is the BactiDomus® Technology which is based on the use of an inorganic limestone-like porous carrier material. The porosity of the material allows it to be bathed in a nutrient broth, absorbing key micro-nutrients that act as an initial food source when the product is activated. It is then impregnated with a range of different naturally occurring and non-pathogenic organisms, selected for their ability to breakdown specific organic contaminants.

The organisms selected for inclusion are selected based on the understanding that each contaminated environment can be aerobic, anaerobic or facultative anaerobic. Therefore, aerobic, anoxic and anaerobic organisms are selected and used in each product to ensure that they can function successfully in a broad range of environments.

The carrier material's large surface area to size ratio provides the organisms with both internal and external floc points where they grow and create large effective colonies of biodegraders working together to break down the organic contaminant into carbon dioxide and water.
The carrier material's hydrophilic nature allows it to absorb both the water and contamination. This provides a steady strong contact between the imbedded organisms and organic contaminant. This ensures that the organisms have a continuous food source as they grow and create flocs within the protective confines of the capillary network of the carrier material.

SITE PREPARATION

On September 2, 1993 the site was prepared by Metcalf & Eddy staff. The protective layers of gravel and fabric covering, originally placed to prevent the spread of PCB contamination, were removed. To control dust and maintain moisture levels in the soil a geo-textile membrane was placed over the exposed site and a sprinkler system was installed. Site preparation work was completed on September 9, 1993.

Equipment was installed on-site on September 16. Sampling locations were marked and lysimeters and tensiometers were installed.

WEEKLY PROCEDURES

For the initial application on September 17, 1993 800 kg of BactiDomus® Technology product 401 was tilled and watered into the soil. On September 20 and every week following, BactiDomus® Technology products were applied as a slurry, to the contaminated soils. A 200 litre container equipped with an electric mixer and pump was set up to mix the BactiDomus® Technology products in water and then spray them onto the contaminated soils. The geo-textile covering was removed prior to the application of the bacteria and then replaced once the application was completed.

A sprinkler system, set to run off a pre-set timer, ensured that the site remained moist and that there was sufficient water to drive the bacteria into the soils. The daily watering also helped, to a lesser extent, to control the surface temperatures of the soils, preventing the top layer of soil from overheating and killing off the bacteria.

RESULTS

It is important to note that all sampling was carried out by Metcalf & Eddy staff and all results in this report were provided to Nordevco my Metcalf & Eddy.

As initially discussed in the Treatability Report submitted to the NJDEPE and corroborated by other work carried out by Nordevco, the use of our BactiDomus® Technology tends to facilitate the recovery of contaminants from the soils by laboratory extraction procedures. As a result, during the initial phase of any project we see an increase in the actual concentrations of the contaminant. This does not mean that biodegradation has not taken place but rather that additional amounts of contaminant have become available for observation and degradation.

It should also be noted that samples of soil taken during testing indicate the presence of more highly chlorinated congeners than are normally associated with Aroclor 1248. The presence of these compounds could be attributed to the increased levels of contaminant available for analysis or to the very non-homogenous nature of the contamination in the soil.

0 - .3 M DEPTH

In terms of actual concentrations of Aroclor 1248 we see an increase from 11 ppm on September 16 to 60 ppm on October 19. The concentration then decreases back to 14 ppm in November's analysis and then rises again to 46 ppm for the December 7 sampling. This is corroborated by the fact that congeners not associated with Aroclor 1248 also become evident. While Standard Method 8080 is not an accurate indication of the biodegradation taking place, it does provide insight into what is taking place. As the amount of bacterial product is added to the site, the amount of initially unaccounted for contaminant that becomes detectable should increase. Yet, while we see a series of peaks and valleys in the results, subsequent peaks are not as high as previous peaks.

While some of the variability will be the result of sampling procedure and the heterogeneity of the soil, the trend to less PCBs 'available' for analysis indicates that biodegradation has taken place.

.3 - .6 M DEPTH

As we do not have any of the Standard Method 8080 data results for this depth, we are limited to using the congener analysis only. As was the case in the 0 - .3 m depth, we again see the presence of congeners associated with more complex Aloclors. While the fluctuations noted in the Method 8080 analysis above are not as pronounced in the congener analysis for this depth, they do exist. However, the results for December indicate a reduction of approximately one third at this depth.

.6 – 1.0 M DEPTH

The results for this depth are far more consistent than for the other depths. Between September and November we observe concentrations that range from 65 to 63 ppm. The December concentrations have dropped to 30 ppm which is approximately a 50 percent decrease. One of the reasons for the absence of fluctuations may be due to a reduced presence of the more complex congeners compared to the other levels.

NEW JERSEY SITE: NUTRIENT ANALYSIS RESULTS

Date	09/16/93	10/19/93	12/07/93
Sample Location	**CC-1**	**CC-1**	**CC-1**
Analyte (mg/kg)			
Potassium	230 B	209 B	329 B
Chloride	19.9	49	29.9
Nitrate	48.6	91	10.1
pH (s.u.)	7.2	8.2	7.1
Total Phosphorous	3.38	50	12.7
TKN	2.73	61	4.54
TVS	3.3%	2.3%	NS
Total Solids	92%	94%	90%
TOC	NS	NS	23.0

Notes:

B = Analyte found in associated laboratory method blank
NS = Not sampled
mg/kg = ppm

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NEW JERSEY SITE: PCB RESULTS

Lab Test: Method 8080, Total PCBs

Sample Location	Sampling Date: 09/16/93			Sampling Date: 10/19/93			Sampling Date: 11/16/93			Sampling Date: 12/07/93	
	K-9 (ppm)	K-6 (ppm)	FB (ug/l)	K-9 (ppm)	K-6 (ppm)	FB (ug/l)	K-9 (ppm)	K-6 (ppm)	FB (ug/l)	K-9 (ppm)	K-6 (ppm)
Depth	0 - 1 ft	2 - 3 ft		0 - 1 ft	2 - 3 ft		0 - 1 ft	2 - 3 ft		0 - 1 ft	2 - 3 ft
Aroclor 1016	1.8 U	3.6 U	2.0 U	3.6 U	3.8 U	1.0 U	3.8 U	3.8 U	1.0 U	3.7 U	3.8 U
Aroclor 1221	1.8 U	3.6 U	2.0 U	3.6 U	3.8 U	1.0 U	3.8 U	3.8 U	1.0 U	3.7 U	3.8 U
Aroclor 1232	1.8 U	3.6 U	2.0 U	3.6 U	3.8 U	1.0 U	3.8 U	3.8 U	1.0 U	3.7 U	3.8 U
Aroclor 1242	1.8 U	3.6 U	2.0 U	3.6 U	3.8 U	1.0 U	3.8 U	3.8 U	1.0 U	3.7 U	3.8 U
Aroclor 1248	11	64	2.0 U	60	65	1.0 U	14	63	1.0 U	46	30
Aroclor 1254	1.8 U	3.6 U	2.0 U	3.6 U	3.8 U	1.0 U	3.8 U	3.8 U	1.0 U	3.7 U	3.8 U
Aroclor 1260	1.8 U	3.6 U	2.0 U	3.6 U	3.8 U	1.0 U	3.8 U	3.8 U	1.0 U	3.7 U	3.8 U

Notes:

U = not detected at the level reported

ug/l = ppb

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CONGENER ANALYSIS RESULTS

	CC-1 0-1 ft				CC-2 1-2 ft				CC-3 2-3 ft			
	09/16/93	10/19/93	12/07/93	Summer '94	09/16/93	10/19/93	12/07/93	Summer '94	09/16/93	10/19/93	12/07/93	Summer '94
Mono – PCB	14.4	24.2	8.8	2.6	170	151	17.4	1.8	2.1	23.2	4.1	2.4
Di – PCB	858	1230	605	798	2120	3540	804	118	644	3400	827	659
Tri – PCB	10400	12100	25400	8740	16000	23800	16500	1470	8070	31900	12300	15110
Tetra – PCB	16500	11300	29400	20800	34900	28800	20700	4780	8740	43100	17200	39910
Penta – PCB	3720	2640	8000	6090	9570	3330	5580	1210	1720	7370	4460	9410
Hexa – PCB	202	140	492	438	412	129	313	147	60.5	201	195	861
Hepta – PCB	93.5	63	179	83.1	163	36.2	112	27.6	22.8	68.7	66.4	236
Octa – PCB	38.7	25	50.6	10.1	41.3	4.1	29.3	7.1	8.7	18.8	17.6	14
Nona – PCB	3.6	2	5.3	7.3	4.9	0.33	3.1	7.7	0.76	2.5	1.7	8.2
Deca – PCB	0.4	0.3	0.47	??4.8	0.35	0.082	0.64	??4.7	0.33	0.29	0.21	??5.6
TOTAL	31831	27525	64141	36974	63382	59791	44059	7774	19269	86084	35072	66216

Note: Some values are estimated

	09/16/93	10/19/93	12/07/93	Summer '94
CC-1	31831	27525	64141	36974
CC-2	63382	59791	44059	7774
CC-3	19269	86084	35072	66216

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SAMPLES OF DEC. 7, 1994

	Absolute Figures				Percentage of Distribution		
	CC-1	**CC-2**	**CC-3**		**CC-1**	**CC-2**	**CC-3**
Mono	13.2	15.1	17.3		0.0	0.0	0.0
Di	592	721	4600		1.9	2.1	2.7
Tri	10150	9550	52780		32.0	28.0	31.1
Tetra	18040	20730	98860		56.9	60.8	58.3
Penta	2510	2720	12040		7.9	8.0	7.1
Hexa	185	93.3	685		0.6	0.3	0.4
Hepta	71.9	41.9	370		0.2	0.1	0.2
Octa	37.8	89.5	110		0.1	0.3	0.1
Nona	96.9	109	122		0.3	0.3	0.1
Total	31696.8	34069.8	169584.3		100	100	100

NEW JERSEY SITE: CONGENER ANALYSIS RESULTS
EXPRESSED ON A MOLE BASIS: 2 - 3 FT.

Depth		2 - 3 ft					
Composite Sample		CC - 3					
Units	Molecular Weight	09/16/93 n mol/g	Mol %	10/19/93 n mol/g	Mol %	12/07/93 n mol/g	Mol %
Mono-PCB	189	0.01	0%	0.12	0%	0.02	0%
Di-PCB	223	2.89	4%	15.25	5%	3.71	3%
Tri-PCB	258	31.28	45%	123.64	40%	47.67	38%
Tetra-PCB	292	29.93	43%	147.60	48%	58.90	47%
Penta-PCB	327	5.26	8%	22.54	7%	13.64	11%
Hexa-PCB	361	0.17	0%	0.56	0%	0.54	0%
Hepta-PCB	396	0.06	0%	0.17	0%	0.17	0%
Octa-PCB	430	0.02	0%	0.04	0%	0.04	0%
Nona-PCB	465	0.00	0%	0.01	0%	0.00	0%
Deca-PCB	499	0.00	0%	0.00	0%	0.00	0%
TOTAL		69.62	100%	309.93	100%	124.70	100%

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