MYCELX TECHNOLOGIES CORPORATION

A TEAM APPROACH

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A Team Approach

A unique combination of remediation technologies works effectively together to remove dilute oil and PCBs from water

by Kirk W. Abbott

Polychlorinated biphenyls (PCBs) were outlawed over 20 years ago because of harmful effects on humans, wildlife and bioorganisms. These chemical compounds are well-known carcinogens. About 1.5 billion pounds of PCBs were manufactured by chemical companies between 1930 and 1975. Before they were banned, PCBs were used in coolants, lubricants, plasticizers, rubberized paints and insulator products.[1]

PCBs have steadily made their way into nature by way of soil and water contamination. One particular culprit is the electrical transformer. Electrical transformer oil, stabilized with PCBs, was used as a coolant or "heat transfer fluid" so transformers wouldn't run hot. Over the years, spent transformer oil has been grossly mishandled. For example, electric companies would actually spray old transformer oil on the ground to control dust at electric switchyards and power stations, not realizing the environmental impact.

This article outlines environmental challenges and solutions for remediating water contaminated with PCBs at one active U.S. Environmental Protection Agency (EPA) Superfund site (Figure 1). It follows with several other case studies that demonstrate the capabilities of HRM™ (Hydrocarbon Removal Matrix) technology, combined with other key remediation technologies, for separating and removing dilute hydrocarbon pollutants from water.

Carolina Transformer Superfund Site -- Case Study 1.0

Years ago, the Carolina Transformer Company (CTC) had an electrical rebuilding and repair operation on a five-acre site in Fayetteville, N.C. After 15 years of operation, the company closed in 1982 and the site was abandoned. During operation, CTC had a storage facility for transformers and other equipment containing transformer oil contaminated with PCBs. The oil was not properly managed, stored or disposed of, and as a result, PCBs made their way into the surrounding acreage and ground water.

Transformer oil and PCBs at very dilute concentrations are extremely difficult to remove from water.

Figure 1.

Consequently, in 1989, the North Carolina Environmental Services Division inspected the abandoned CTC site. The soil and groundwater contamination was confirmed, and the land was designated an EPA Superfund site under the Comprehensive Environmental Response, Compensation and Liability Act (also known as CERCLA or Superfund).

After many years of cleanup assessment, contractor proposals and red tape, 301 Environmental Services Corp. (Fayetteville, N.C.) was awarded a contract in January 2002 to treat and remove trace PCBs from over 1,500,000 gallons of contaminated water at this site (Figure 2). The level of PCBs in the water had to be reduced below 0.5 parts per billion (ppb) to conform with the discharge allowances of the state of North Carolina to the nearby Cape Fear River.

Figure 2.

The Challenge

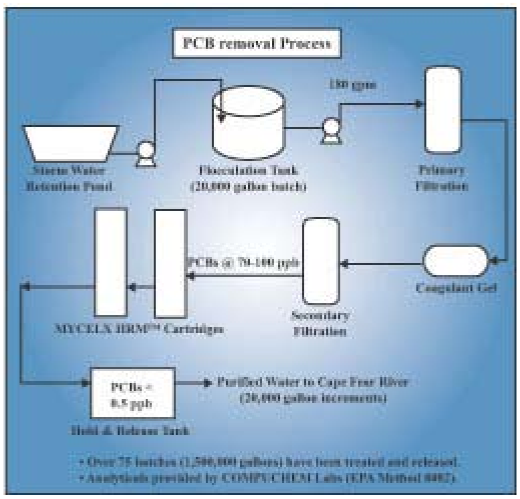
A very low PCB discharge level (0.5 ppb) was required. In addition, transformer oil and PCBs at very dilute concentrations are extremely difficult to remove from water. This is especially complicated when mud, silt and clay are in the mix, which can all act as micro-absorbents and carry PCBs. Standard flocculation and filtration attempts could only achieve 70 ppb to 100 ppb PCB levels. The other problem with suspended solids like clay and silt is, due to their type and size, they clog and blind-off filter media very quickly. Large backpressures develop rapidly. Tiny clay and silt particles carrying PCBs break up and bypass standard filters that don't capture sub-micron (<1 micron) particles.

In short, purifying water with trace oil, PCBs and sub-micron particulates such as silt and clay, is a very difficult, expensive and time-consuming endeavor. Typically impacted water of this type must be transported and treated off-site or ex-situ. As well, meeting discharge limits of 0.5 ppb on-site or in-situ has, historically, not been economically feasible.

To meet this challenge, 301 Environmental Corp. asked MYCELX Technologies Corp. (Gainesville, Ga.) to design a complete pump and treat separation system to remove the PCBs and purify the water in-situ for discharge to the Cape Fear River.

The Solution
MYCELX Technologies, the manufacturer of MYCELX HRM™ (Hydrocarbon Removal Matrix) technology that is designed to bond and separate select hydrocarbons from water, in conjunction with the developers of a natural coagulant gel (provided by Engineering Sales Associates of Charlotte, N.C.), were able to develop an effective and economical (in-situ) system capable of processing water at 180 gallons per minute (gpm)(Figure 3).

Figure 3.



To date, over 1,500,000 gallons of water have been purified to below detectable limits (BDL) of PCBs (<0.5 ppb) and discharged to the Cape Fear River.

To produce this success, a combination of four technologies were used:

- Flocculation with select polymer additives (20,000 gallon batches).
- Particle Filtration -- a series of vessels and high efficiency filter media were used to remove particles to less than 1 micron.
- During the evolution of this project, a filter-aid product was added to improve the particulate filtration and associated pressure drops. The product is a natural coagulant gel called Chitosan. As this gel slowly dissolves, it attracts sub-micron particles, which agglomerate into larger, stable, easier-to-filter particles. This technology was very important to the over-all success of the project due to the type and size of suspended solids (i.e. sub-micron silt, mud and clay). The gel

was implemented after gross particle removal at 50 microns and before fine particle removal.

- HRM Cartridges have an extremely strong bonding attraction for select hydrocarbon compounds. In this application, the HRM™ Cartridges removed the PCBs to below detectable limits (BDL)(Figure 4). It is important to note that HRM Cartridges actively bond to hydrocarbons without desorption and operate at less than one pound per square inch (psi) pressure drop up to their saturation point (HRM Cartridges: A Definition).

Figure 4.

Additional Case Studies: Oil and Chlorinated Hydrocarbons
The extent of the PCB problem is, of course, not limited to this one Superfund site in North Carolina. This problem exits at many other locations where electrical equipment containing PCB-contaminated capacitors and transformers are found. Fortunately, treatment systems using HRM cartridges that removed the dilute oil and PCBs from the water at the Superfund site have also been successfully applied to other sites having difficulties removing PCBs to the discharge levels mandated by law. The following case studies illustrate the versatility of the remediation system developed by MYCELX.

PCB Electric Utility Application -- Case Study 2.0
The utility industry -- seeking to protect the environment while at the same time reducing the risk of fines, costly cleanup efforts and unwanted public scrutiny -- is striving to prevent oil and PCB contamination of soil and water.

For utilities, the problem occurs primarily in manholes and at transformer yards where stormwater is exposed to old transformers and capacitors that have oil or fluids that contain some PCBs. In order to perform maintenance, the stormwater (containing traces of oils, lead and PCBs) must be pumped out of the manholes and retention wells, and treated before it can be discharged to the environment or municipal sewer systems -- an expensive process for any organization.

For one utility, this practice -- excluding pumping and transportation of the water to a treatment facility (i.e."ex-situ" treatment) -- costs over 25 cents per gallon. JoDAN Technology Ltd. (JDT) was asked to develop an in-situ treatment system to address the oil/PCB contaminant concerns. In cooperation with the electric utility, JDT developed the JMOR™ System consisting of particle filtration and HRM Cartridge units.

In June 2000, JDT built and began testing the first system. After four months of operation, the system processed 1,300,000 gallons of manhole wastewater at a cost of only 2.8 cents per gallon. The system removed PCBs, oil, grease and other hydrocarbons to BDL. As an expected bonus, the system also removed the lead and copper from the effluent water (**Table 1.0**).

Table 1.0 -- Results from treating 1,300,000 gallons of manhole water.

	PCB1254	TPH	Oil & Grease	Lead	Copper
	ppb	ppm	ppm	Avg. ppm	ppm
HRM Effluent	<1.0	<5.0	<5.0	0.020	<0.01
Avg. Influent	3.74	367.9	17698	33.0	11.6
Max. Influent	40.0	21400	141000	150.0	87.0

*All PCB samples were below 1.0 ppb.

*All PCB samples were analyzed as PCB Aroclors by the utility company.

*The lead and copper removal was due to the metals existing as organo-metallics.

Nuclear Power Plant Radioactive Liquid Waste with PCBs - Case Study 3.0
The nuclear power industry is currently searching for effective solutions for removing oil, PCBs and radionuclides from radioactive liquid waste. Duratek Corp. (Columbia, S.C.) processes radioactive liquid waste for a U.S. nuclear power plant. At this facility, the liquid waste treatment process basically consists of beds loaded with activated carbon and various ion exchange resins, preceded by particle filtration for suspended solids. The challenge here is to remove all traces of oil, PCBs and radioactivity, and to polish the water to Grade A purity for discharge and/or reuse within the plant. Meeting discharge limits for PCBs in this case requires levels below 65 ppt (parts per trillion). Carbon and ion exchange polishing systems are simply not effective at meeting these extremely low levels with such a complex liquid waste. As well, oily compounds in liquid waste cause carbon and ion exchange beds to load rapidly, plug-up and break-through much quicker than normal, crippling efficiency and generating large volumes of hazardous waste.

In January 2003, HRM cartridges were evaluated for their ability to remove oil, PCBs and radionuclides to below detectable limits. After successful testing, the nuclear power company ordered a full-scale system from JoDAN Technologies of Glen Mills, Pa. (consisting of five micron particle filtration and HRM Cartridge units) to remove the all the oil and PCBs (down below 65 ppt), and knockdown radionuclides from the radioactive liquid waste at 60 gallons per minute. After HRM pre-treatment, the carbon and ion exchange beds can then be used for only trace components, and in turn will last several times longer. This combination of technologies provides consistent water polishing to ultra-pure standards without clogging and plugging up, while reducing hazardous waste up to 100 times.

The utility industry -- seeking to protect the environment while at the same time reducing the risk of fines, costly cleanup efforts and unwanted public scrutiny -- is striving to prevent oil and PCB contamination of soil and water.

PCB Contaminated Landfill Leachate and Discharge Water -- Case Study 4.0
An owner of a PCB-contaminated landfill in the North East United States, requested technical support to remove trace oil and PCBs from the landfill's stormwater run-off and leachate. A single HRM cartridge unit was placed downstream of an existing particle filter and sand filter. In this case, the discharge limit was extremely low at 65 parts per trillion (ppt). Results are listed in **Table 2.0**.

PCB Contaminated Industrial Wastewater -- Case Study 5.0
An industrial manufacturer generates PCB-contaminated water that results from decommissioning electrical equipment containing PCB contaminated capacitors and transformers. The cost to have the wastewater shipped off-site and treated was over $1.00 per gallon. JoDAN Technologies Ltd. utilized HRM Cartridges and treated the wastewater on-site for less than $0.05 per gallon. The results are also reported in **Table 2.0.**

Table 2.0 -- Results for PCB Case Studies 4.0 and 5.0

	Land Fill **(HRM Standard Formulation)** **PCB 1254** **2.5 gpm**	**Manufacturer** **(HRM Standard Formulation)** **PCB 1254** **5 gpm**
Influent	129 ppt	174 ppb
Effluent	BDL(<65 ppt)	BDL (<1.2 ppb)

Other Applications
Rapidly separating dilute oily hydrocarbons and solvents in a single-pass without restricting flow is novel and creates newfound economics for treating hydrocarbon-contaminated water. Treatment systems employing HRM technology prior to discharge or before polishing

technologies, such as reverse osmosis or deionization, are more robust and generate savings by reducing energy, equipment, raw material, chemical, maintenance and downtime requirements.

HRM technology is allowing industry to more effectively address in-situ wastewater discharge, process water recovery, water reuse and zero liquid discharge (ZLD). Applications also include boilers (i.e. condensate water), cooling towers, chillers, swimming pools and other close-loop water systems contaminated with dilute hydrocarbons.

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3. Abbott, Kirk and Alper, Hal. "Protection from Organic Fouling." *Environmental Protection.* June 2001, Volume 12, Number 6, pp. 34-40.*

[* To access articles published in *Environmental Protection*, go to www.eponline.com, click on "Archives" and search by title.]

HRM Cartridges: A Definition

HRM cartridges are polypropylene filter cartridges infused with a special polymer compound that actively bonds to hydrocarbons. The polymer compound, known as MYCELX®, is formed as a synthesis product of natural drying, semi-drying, and non-drying oils with a synthetic polymer [Composition Patents: 5,437,793 and 5,746,925 / Chemical Abstract Service (CAS) #173967-80-1 and #173967-81-2].

The polymer is infused and cured into a variety of substrates (i.e. filter cartridges and absorbent materials) so that it is homogeneously dispersed throughout the base material(s). As hydrocarbon compounds come in contact with the polymer, they are dissolved and bonded to, and will not re-disperse or emulsify into water.

HRM cartridges are engineered to remove petroleum-type hydrocarbons ranging from oil to gasoline, including BTEX compounds -- benzene, toluene, ethylbenzene and xylene(s) -- at up to 99.9 percent in a single-pass without significant pressure drop or clogging (roughly 0.5 psi to saturation).[2] The cartridges can separate oil-water mixed emulsions and remove semi-soluble compounds. The cartridges are proven effective in removing alkanes, alkenes, cycloalkanes, aromatic hydrocarbons (BTEX), crude oils, vegetable oils, complex monomers, polymers, organo-metallics, PCBs, methyl tertiary butyl ether (MTBE) and chlorinated organic compounds.[3]

The cartridges are extremely hydrophobic and will not absorb water. Typically, oil sorbents and filters absorb many times their weight in water. HRM cartridges only absorb hydrocarbon-based pollutants, so when saturated, only the cartridge and the pollutant are left (i.e., no residual water). The cartridges are non-hazardous, non-toxic and are declared compliant to section 300.915 of the National Contingency Plan under the Clean Water Act. They are easily disposed of by incineration. They have an extremely light water drag-out and low ash content, resulting in a clean burning waste with a British Thermal Unit (BTU) value comparable to alternative fuels. In terms of disposal requirements, the hazardous nature of the HRM Cartridges are dictated by the absorbed/adsorbed contaminants. In many cases, petroleum-saturated HRM can be disposed of in municipal landfills that are permitted to handle non-hazardous sold waste like other petroleum-saturated materials (i.e., oily rags, sorbents and oil filters).

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