Removal of VOCs in a Fixed Film Bioreactor at Groundwater Remediation Site

Aerobic bacterial count increased 10,000 fold and hydrocarbons dramatically decreased

The Problem

The Eastham, MA library purchased the property adjacent to the library for the purpose of converting the lot to parking. When clearing the land, it was discovered that the fuel oil tank in the basement of original building had been leaking oil into the ground for an unknown number of years. As is common on Cape Cod, the building had been built on sandy soil, and therefore the leaking oil had reached and contaminated the aquifer over the years. As groundwater is the principal source of domestic water supplies on Cape Cod, this groundwater remediation project was given a high priority by the town of Eastham.

A two step solution is described here:
1. Use a Venturi Aerator to saturate the water with dissolved oxygen.
2. Add HD Q-PAC to provide an extremely large, ideal surface for bacteria to colonize.

The Solution - Part One

The town hired an engineering firm, Bennett & O'Reilly, with wide experience in groundwater remediation projects. The engineer consulted with Venturi Aeration to devise a biological decontamination solution. The primary problem with a biological solution is that the concentration of dissolved oxygen in the groundwater is normally under 2 ppm.

Venturi Aeration's patented O_2 transfer system solves this problem. The Venturi Aerator raises the dissolved oxygen in the water up to 10 ppm. This enhanced concentration of oxygen supports elevated levels of biological activity. The elevated bacterial level then converts the carbonaceous oil to CO_2 and H_2O. The Venturi Aerator is not large. This allows for a constant recirculation treatment system to be housed in a very unobtrusive outbuilding. The shack containing the treatment system appears to be an ordinary utility building (see figure 1). **See appendix 1 at the end regarding how the Venturi Aerator works.**

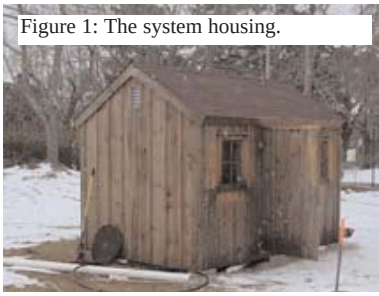


Figure 1: The system housing.

The Solution - Part Two

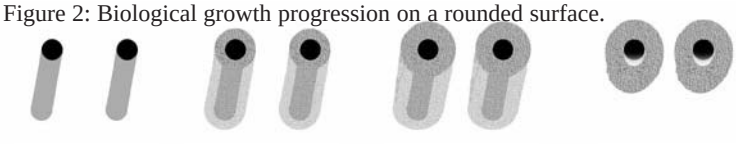
Although the initial destruction of hydrocarbons in the water was promising, it was determined that hydrocarbon removal efficiency could be improved further by increasing the level of biological activity. A common method used to achieve this goal is to add a plastic media (or packing) to the water. The packing media supports increased biological growth by giving the bacteria additional surface on which to colonize.

The media used was HD Q-PAC provided by Lantec Products. This media was made to support a biological colony on its rounded surfaces, many small rods, and extremely high surface area (dry, 132 ft^2/ft^3). A rounded media assures that the actual surface of the biological colony will be some factor greater than the supporting surface of the media itself. Additionally, a round support media offers a number of other major benefits:

1. The effective surface of biological colony must be greater than the specific surface of the media.
2. The media is self cleaning.
3. As biological growth sloughs off the media, the water is seeded with useful bacteria.
4. The biological colony remaining on the media is maintains an active growth phase so that the maximum amount of nutrients (fuel oil hydrocarbons) are consumed.

These points are illustrated below:

Figure 2: Biological growth progression on a rounded surface.



Four cubic feet of HD Q-PAC was added to the underground tank February 1, 2003. When separated into pieces of several layers each this was enough media to assure that the entire surface of the water was covered with media. With a specific gravity of 0.91, most of the polypropylene HD Q-PAC so loaded into the tank was floating just below the surface of the water.

A total surface area of almost 528 ft^2 became available for support of bacterial growth.


Fig. 3: Biofilm development.

After 6 weeks, the water was tested for active biological colonies. The results of this testing were:

Before Addition of HD Q-PAC: 10^3 active colonies per cm^3
After Addition of HD Q-PAC: 10^7 active colonies per cm^3

Therefore a 10,000 fold increase in biological activity was accomplished with the addition of HD Q-PAC into the groundwater.

The well developed biofilm on the HD Q-PAC can be noted in figure 3.

Fuel Oil Contamination Reduction
The reduction of organic compounds in the groundwater is charted in Figure 4a and 4b.

These efforts led to the following results:

1. The water being returned to the Eastham aquifer is within state mandated discharge quality parameters.
2. There is no evidence of hydrocarbon contamination in three monitoring wells.
3. Wells that supply drinking water on adjacent properties are now considered to be safe from contamination from this site.

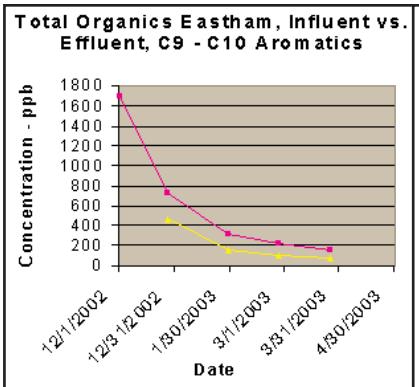


Figure 4a. C9 - C10 Aromatics detected in Eastham groundwater

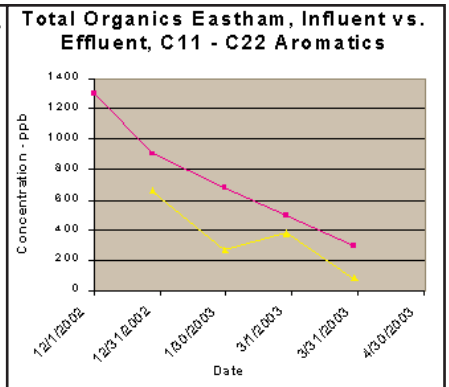
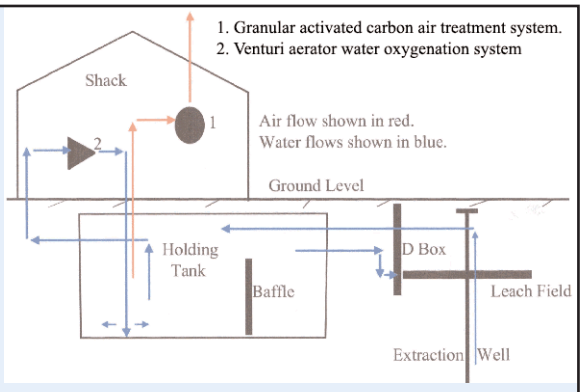


Figure 4b. C11 - C22 Aromatics detected in Eastham Results

Appendix 1: How the Venturi Aerator Works

This remediation solution is presented here. The level of the water table is about 30 feet below the surface. The extraction well pulls water from 35 feet below the surface. The flow from the well is 15 gpm. This water is discharged onto the surface of the water in the modified septic tank that is below the shack. The normal volume of the reservoir of water being held within the tank is 800 gallons. The temperature of the water, even in midwinter conditions, is 60 °F. The pH of the water is generally 6.6 in the influent, 6.9 in the effluent.



The water that is recirculated through the Venturi Aerator is pulled up from inside the reservoir within the tank by a 100 gpm recirculation pump that is inside the shack. The normal operating flow of this pump is 50 gpm As this water passes the Venturi Aerator the dissolved oxygen level in the water is raised from < 2 ppm to > 7 ppm. The oxygenated water is then returned to the bottom of the reservoir in the tank. This water is diffused into the bottom of the reservoir by passing through $^3/_8$" perforations in the bottom of the discharge line.

Treated water is removed from the tank at 15 gpm and returned to the ground via a D Box and then a leach field above the extraction point. There is a baffle installed in the tank between the discharge to the ground and the discharge of oxygen rich water. In addition to biological action within the reservoir, some volatile organic compounds are stripped from the water in this process. The exhaust air containing these organics are captured and passed through an activated carbon unit which adsorbs the organic vapors. This air is then vented from the shack. The air treatment portion of the system is noted in the figure.

Additional contributors to Case Study 43:

John M. Salonich
Venturi Aeration
www.venturi-aeration.com
603-635-8239

David C. Bennett
Bennett & O'Reilly Engineering Services
508-896-6630