**Technology Review**

Innovative Environmental Technologies, Inc.

## Ex-Situ/In-Situ Enhancement Trailer

In-situ biodegradation occurs through the action of naturally-occurring microorganisms which are encouraged to grow through addition of nutrients, oxygen, organic substrates or other materials. If naturally-occurring organisms are absent or few in number, or when a more rapid clean-up is desired, acclimated organisms are added to the surface environment. By combining the two approaches (organism addition with an enhanced environment for growth) a rapid and continuous remediation may take place.

The degradation of petroleum hydrocarbons can be approximated by first order kinetics. The concentration at any given time is given by $L = L_0e^{-Kt}$ where:

- $L$ = concentration at time t
- $L_0$ = initial concentration at t = 0
- $t$ = time in hours
- $K$ = first order rate constant as determined from empirical data

The rate constant is determined by the conditions under which the system is operating. For a biological reaction to proceed oxygen, nutrients, pH, water, substrate, and microbes must be present in the correct proportions. Quite often one or more are not present in sufficient quantity or is not at an optimum level for the reaction to proceed at a rapid rate. The missing element then becomes the rate limiting step of the biological reaction. The objective of a successful remedial program is to optimize all the elements necessary for the management of an efficient environment.

A bioreactor takes all of these conditions into consideration and allows the operator to control the reaction by adjusting these factors. Ultimately, what the operator changes is the rate constant.

The maximum oxygen level possible in water through aeration is 8 ppm. As the microbes consume the existing oxygen, additional oxygen is required, either from the groundwater flow or outside oxygen sources. Typically, in low-flow groundwater's,

oxygen is most often the rate limiting step in the biodegradation of petroleum hydrocarbons.

Nutrient concentrations are determined on a chemical oxygen demand (COD) basis. For every pound of hydrocarbon present a certain quantity of nitrogen, phosphorous, and micronutrients are required for complete mineralization to $CO_2$, water, and biomass. In this case the biological oxygen demand (BOD) can be approximated as being equal to the COD. Current literature cites C:N:P ratios of between 100:15:1 to be 100:5:1 - thus for every 100 pounds of hydrocarbons present, 5 pounds of nitrogen and 1 pound of phosphorous are required to completely degrade all available hydrocarbons. To successfully maintain these rations in-situ becomes particularly difficult, particularly in the unsaturated zones.

pH in an aqueous system is perhaps the easiest parameter to control. pH is adjusted by the use of acids, bases, and buffers. The optimum range for microbial growth is between 6.5 and 8.0 with neutral or 7.0 being the ideal.

The substrate or hydrocarbon source must be available is sufficient quantity to sustain a healthy microbial population. The microbial population is proportional to the hydrocarbon concentration under normal conditions. As the substrate concentration decreases the microbial population will normally decrease as well. In order to sustain an elevated microbial population, a constant source of degradable hydrocarbons must be available.

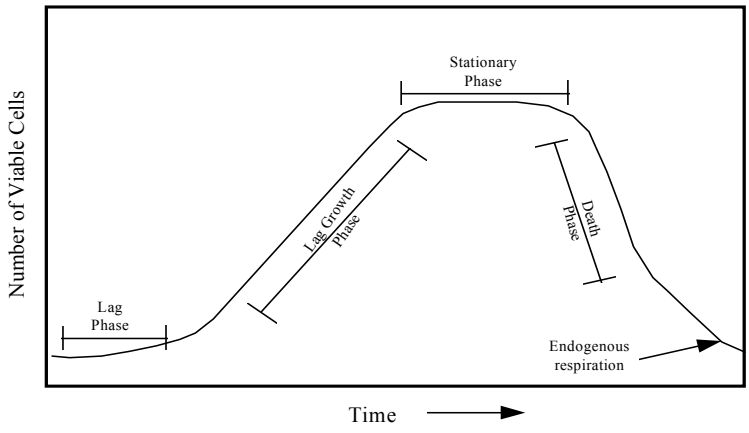
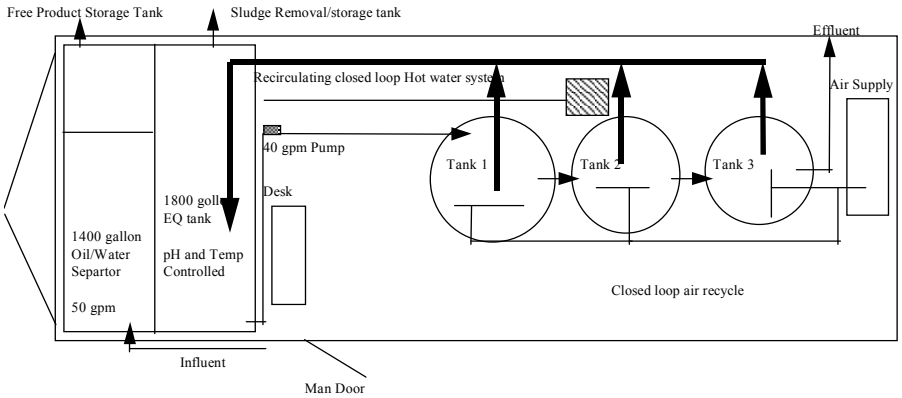



**Figure 1**

The microbial population in-situ can be difficult to maintain at optimum levels as the petroleum hydrocarbon concentration changes. A graphical representation of the Bacterial Growth in a Batch System is included in Figure 1. The optimum range is the stationary phase in which a large viable population is present at all times. A change in any of the previously mentioned parameters can cause the system to enter one of the other phases, thereby reducing the effectiveness of the entire system. By using custom microbial blends,, managing the population, Innovative Environmental insures all the necessary microbes are present in the correct proportions for the targeted contaminants.

A sequential batch, continuous flow reactor design is used for the population optimization and the degradation of targeted compounds

The trailer system is capable of separating free oil and treating the dissolved phase BTEX components of the stream based on a flow of no more than 20 gpm and total BTEX compounds of 17,500 ppb. Free product recovered can be stored and removed from the system. Treatment efficiency is expected to be equal to or greater than 99% on BTEX compounds.




System Description: The Mobile treatment system contains a total of 4000 gallons of aqueous tankage + the O/W separator. At 40 gpm the hydraulic retention is approximately 100 minutes. The control panel monitors and records flow, pH and temperature. The PLC has the capability of controlling five separate extraction sumps. The thermolux heater is capable of raising the temperature of the water in the EQ tank a maximum of 10 degrees based on a 40 gpm flow. Temperature and pH is controlled by the PLC.