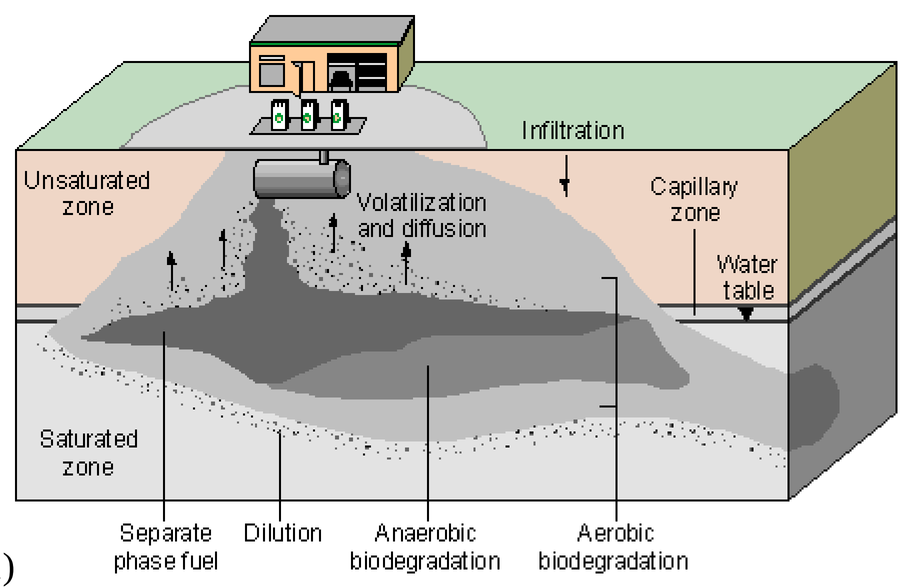
Environmental management technique

تقنية المعالجة البيئية

Lab.5

Natural Attenuation Technique

Natural attenuation also called intrinsic remediation, where remediation relies on natural processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants (Figure 1).



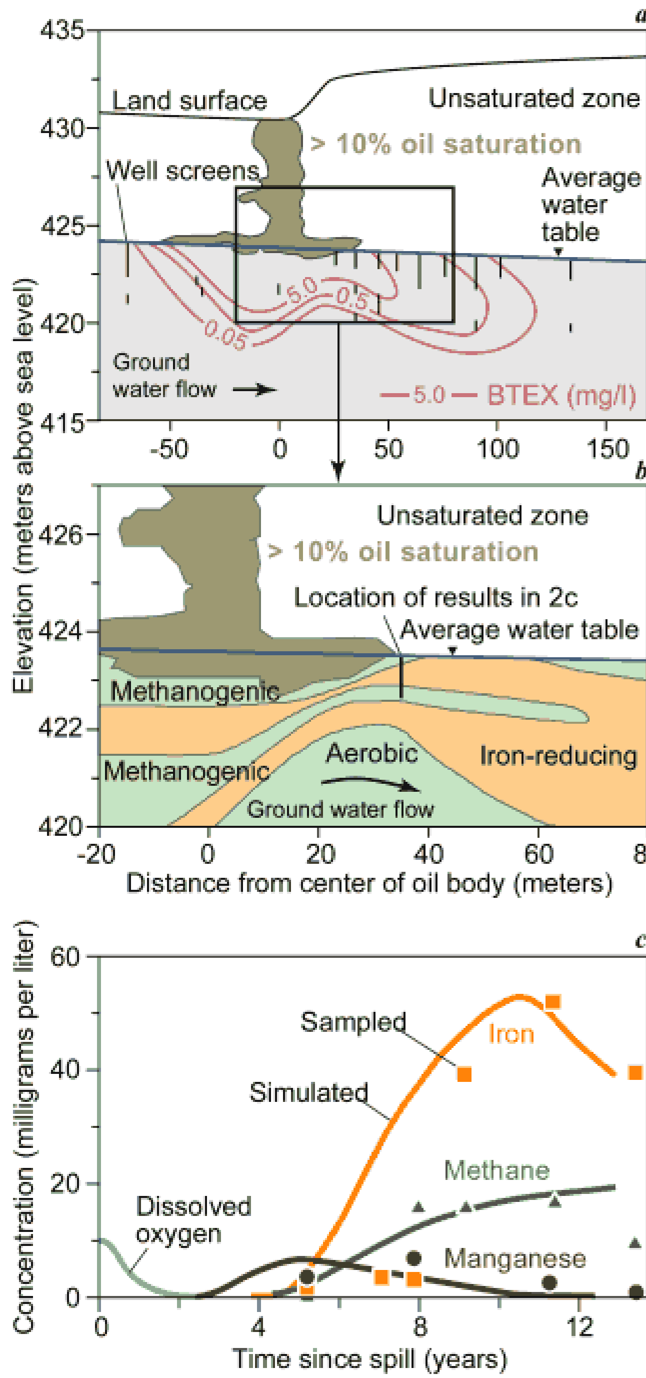
(Figure 1)

Thus, natural attenuation can minimize risks from a wide range of organic and inorganic contaminants. Natural attenuation has been proven to work reliably mainly for gasoline (BTEX). Recently, natural attenuation has been proposed also for chlorinated solvents, nitroaromatics, heavy metals, radionuclides, and other contaminants.

Intrinsic in situ bioremediation is best applied in situations in which the groundwater contains naturally high concentrations of electron acceptors and adequate concentrations of nutrients, consistent groundwater levels and flow velocity, and the presence of carbonate materials to buffer pH changes.

A Case of Study: Spilling of Crude Oil

A buried oil pipeline located in a glacial outwash plain near Bemidji, Minnesota, ruptured in 1979 and an estimated 3,200 barrels of spilled oil infiltrated the subsurface. The oil forms a long-term, continuous source of hydrocarbon contaminants that dissolve in and are transported with the groundwater (Figure 2a). Microbial degradation of the petroleum hydrocarbons in the plume has resulted in the growth of aquifer microbial populations dominated by iron-reducers, fermenters, methanogens, and aerobes (Figure 2b). The biodegradation reactions cause a number of geochemical changes or diagnostic footprints near the aqueous plume. These include decreases in concentrations of oxygen and hydrocarbons and increases in concentrations of dissolved iron, manganese, and methane (Figure 2c). Characterizing the various biodegradation processes occurring in the aquifer is important because each process results in different degradation rates for the individual hydrocarbon compounds. Simulations of the evolution of redox zones and microbial populations in the plume provide important insights, including estimates of losses due to each biodegradation process and the long-term sustainability of the hydrocarbon degradation. A vertical cross-section parallel to the direction of groundwater



(Figure 2)

flow was simulated from the time of the spill in 1979 until September 1992 using the code BIOMOC [BIOMOC is a flexible model that can be adapted to many biodegradation settings. The user specifies the solutes and microbial populations involved in each biodegradation process, and multiple biodegradation processes that occur simultaneously or sequentially can be simulated. Simulations can be designed to represent aerobic and anaerobic degradation of individual hydrocarbons as well as chlorinated solvents. Simulations of this type are useful in assessing the potential for natural or enhanced bioremediation]. In the model, aerobic, Mn and Fe reducing, and methanogenic aquifer microbes degrade the dissolved hydrocarbons. Aerobic degradation takes place first, and oxygen inhibits anaerobic processes. As oxygen is consumed and an anoxic zone develops, the Mn/Fe reducers and methanogens begin to grow, consuming solid-phase Mn(IV) and Fe(III), and releasing dissolved Mn(II), Fe(II), and methane.

The model calibration involved balancing the observed spatial and temporal variations of hydrocarbons against the other degradation reactants and the observed microbial populations. Steady-state flow was assumed, and literature values, theoretical estimates, and field biomass measurements were used to obtain reasonable estimates of the transport and biodegradation parameters. Simulated concentrations and data in Figure 2c illustrate how the evolution of redox zones results in changes in water chemistry over time. The simulation predicts that 60% of the hydrocarbon degradation occurs anaerobically (Mn reduction: 5%, Fe reduction: 19%, methanogenesis: 36%) and 40% occurs aerobically. The field data, modeling, and microbial population results illustrated in Figure 2 suggest that the natural attenuation capacity of the aquifer near the oil is being slowly consumed. This has been confirmed by monitoring of the site over the 20 years since the spill.