ORC TECHNICAL BULLETIN #2.5.1

Oxygen Release Compound, ORC®

Oxygen Distribution in an Aquifer

The movement of oxygen from an ORC particle, to the environment where remediation takes place, is governed by the laws of mass transport. These include Darcy's Law (Advective Flow) and Fick's Law (Diffusion). In addition, some of the kinetic energy released when ORC reacts with water can facilitate dispersion.

In most cases involving the distribution of oxygen in groundwater, advective flow is dominant and the distribution of oxygen by this mechanism can be approximated using flow models. Diffusion is usually a small part of these models, but can become more important in the result as advection is diminished. A pure diffusion model will predict the distribution of oxygen in a static system.

If contamination is present, as in the case with hydrocarbons, then the distribution of oxygen in the aquifer is altered for several reasons. Not only is oxygen consumed by microorganisms in the remediation of hydrocarbons, but certain physical phenomenon affect the movement of oxygen and hydrocarbons differently.

To be specific, oxygen distribution patterns are derived through models as a function of several physical phenomena including: advection, dispersion, retardation and utilization. Advection is essentially groundwater velocity. Dispersion is a multi-component phenomenon that involves several forces including groundwater velocity, dispersivity and diffusion. Retardation is a sorption phenomenon and utilization relates to the oxygen consumption by physical and chemical means.

Advection essentially affects dissolved phase hydrocarbons and oxygen equally, but its influence is masked in minimal groundwater velocity systems. Dispersion is partly composed of diffusion and that can vary with different compounds. The diffusion of oxygen is significantly greater than the diffusion of hydrocarbons in water and an oxygen front can "catch-up" to a contaminant front. Conversely, Retardation can have a greater affect on contaminants than on oxygen, which essentially has no retardation coefficient -since it does not stick to surfaces in a non-reactive status. Utilization is what we want. It describes the reduction of oxygen as a function of use in remediating hydrocarbons.

Oxygen distribution will, of course, vary from site to site. Understanding the distribution is most important when ORC is being used downgradient from the source to prevent contaminant migration off property. Field experience, models and, perhaps a pilot test may be used to predict oxygen distribution and establish the well spacing for this purpose. In our experience, the ORC well spacing for an oxygen barrier where plume cut-off is the objective will be no greater than 12 feet on center and no less than five. Also, an iterative approach may be used where the initial wells are placed further apart and then additional wells are drilled where contaminant breakthrough is observed. Knowing exact oxygen distribution is less important when the ORC is placed upgradient near the source of the contamination and the objective is total plume contraction and clean-up to a RBCA closure standard.

Technical Bulletin 2.5.2 presents the results of oxygen distribution from a field demonstration. Technical Bulletins 2.5.3 and 2.5.4 present the output from an analytical solution to the advection - dispersion equation as described by Cleary and Ungs.

Technical Bulletin Index||Regenesis Home Page