ORC TECHNICAL BULLETIN #2.1.1

Oxygen Release Compound, ORC®

Source Treatment Applications - Saturated Zone

BACKGROUND

ORC may be used upgradient, near the original source of contamination to retract the plume towards the source, permitting a compliance point closure to be met. In this application ORC can be used to address contaminant loads in the higher dissolved phase range (10-100 ppm).

ORC may be applied to the subsurface in completed monitoring wells that allow the use of exchangeable filter socks, or by the use of direct push or augered holes into which a grout-like slurry of ORC is applied. When an excavation of the source areas is planned, there are soil mixing applications that can be considered using ORC powder; these applications are considered separately in Technical Bulletins 2.1.2, 2.3.1, and 2.3.2.

APPLICATIONS

The ORC applications discussed are directed at site closure. With new regulatory guidelines in process closure may be achieved as a function of the compliance requirements which will range from MCL to RBCA standards. In a RBCA framework, risk reduction is tied to mass reduction such that attenuating the source will allow target levels at the compliance point to be achieved.

The "near field zone" is the primary target for ORC application. We define the near field zone as the dissolved phase and the sorbed material located within the saturated zone and capillary fringe. Smear zones can be treated as an additional measure to guard against recharge to the near field zone. NOTE: source areas that have free product are not amenable to ORC applications. The application of ORC in the vadose zone is under development.

ORC REQUIREMENTS

REGENESIS staff is available on request to help in planning a source treatment application. For illustrative purposes we will consider two different ORC application scenarios.

SCENARIO 1:

Remedial Objective: Remediate the source area to MCL or RBCA standard. The compliance point is within the source area.

Dissolved Phase Contaminant Level: 10 parts per million

Ground Water Velocity: 0.2 foot per day

Near Field Sorbed Mass Factor: 8

Source Area Dimensions: 50 feet X 50 feet

Contaminated Saturated Zone: 15 feet

Porosity: 0.3

Recommendation for Scenario 1:

In this scenario there is approximately 7 pounds of dissolved phase contamination in the contaminated saturated zone. The additional near field sorption factor of 8X is used to account for sorbed material in the contaminated zone, such that the total contaminant level is estimated to be eight times the level of the dissolved phase measurement.

Barring direct measurements of sorbed material one can assume a range of 6X to 10X for this variable. Usually a lower value applies to sand and a higher value to clay. A 8X value is used in this example.

The total load in the system is therefore 8 X 7 = 56 pounds of contaminant. Based on an oxygen to carbon stoichiometry of 3:1, and an ORC oxygen content of 10%, there is a requirement for 1,680 pounds of ORC directly into the contaminated zone to remediate the targeted contaminant mass.

The cost of ORC is $16,800 (based on a cost of $10 per pound) and is applied by backfilling the ORC as a slurry via 69 Geoprobe-type holes, 1 3/4 inches in diameter, spaced approximately 6 feet on center. In this example, the full dose can be made in a single multi-day application.

SCENARIO 2

Remedial Objective: Meet a RBCA standard at a compliance point 10 feet downgradient of source well.

Dissolved Phase Contaminant Level: 30 parts per million

Ground Water Velocity: 0.2 foot per day

Near Field Sorbed Mass Factor: 8

Source Area Dimensions: 50 feet X 50 feet

Contaminated Saturated Zone: 15 feet

Porosity: 0.3

Recommendation for Scenario 2.

In the context of risk reduction, which is being implemented through the recent ASTM RBCA guidelines, attenuation models can now be incorporated. Closure standards now take on a different posture. One no longer has to consider total mass removal at the source, but rather a percentage reduction of the concentration so that contamination at a downgradient compliance well is reduced and maintained at an approved level.

We recommend using the Buscheck-Alcantar attenuation model for intrinsic ("natural") attenuation and overlaying the ORC effect in order to 1) reduce the source and 2) enhance the rate of remediation, thus bringing about site closure more rapidly.

The full details of the model, which is a modified form of the Dominico analytical solution to the general one dimensional transport equation with first order decay, are available upon request. In brief, the solution for the concentration at the point of interest (Cx) is determined as a function of time and distance downgradient with respect to the initial concentration (Co) and rates of attenuation. ORC will 1) reduce Co and 2) increase the rate of attenuation (λ) by increasing the oxygen content.

With respect to our example we have the following:

1. A 30 ppm dissolved phase plume is being addressed recognizing there is desorption related recharge from the sorbed fraction of the near field system.

2. A groundwater velocity of 0.2 foot per day.

3. A compliance point is 10 feet downgradient and it would take approximately 50 days for that point to be reached by water from the source treated area.

4. The RBCA standard for the downgradient compliance point is 250 ppb which reduces the health risk to 10^{-5}.

The solution is similar to that in Scenario 1, except only 1 inch diameter holes are required. The emplacement of 69 ORC backfilled holes in the 50 feet X 50 feet target zone will cause the compliance well 10 feet directly downgradient to reach 246 ppb using the Dominico calculations. Without ORC the downgradient well would be 20,110 ppb under the same conditions.

This operation would require approximately 500 pounds of ORC at a cost of $5,000 (at $10.00 per pound of ORC). However, what is still not addressed is that this initial charge only cleans up the dissolved phase portion of the near field system; taking 30,000 ppb to 246 ppb. Recharge is still an issue even though desorption is a slow process. Since RBCA standards require compliance for a specific number of years to attain closure, additional repetitions of the above treatment may be required.

Based on the longevity of the ORC slurry (estimated to be about 6 months), one would have to consider three to six re-applications to closure.

Typical Geoprobe-style costs for 69 holes and ORC combined is about $12,000 bringing the cost of this program to between $12,000 and $72,000, depending upon the mass recharge from desorption.

A final alternative is to approach the site with the same full-scale treatment as discussed in the first example, where the full source is targeted for remediation. This condition has a higher mass and therefore will involve a larger application of ORC. In this case the entire result is increased by a factor of 3 by increasing concentrations from 10 to 30 ppm (with the same factor of 8X), one would require 5,040 pounds of ORC at a total cost of $50,400. The logistics would simply involve reducing the spacing to 3.5 feet on center with the same 1 3/4 inch diameter hole.

Table 1 gives a cost comparison of all the solutions to the two cases presented. These provide guidelines that cover the two dominant costs - the delivery process and the ORC.

Table 1

APPLICATION	DELIVERY COST	ORC COST	TOTAL
Scenario 1			
Full Source Treatment	$6,900	$16,800	$23,700
Scenario 2			
RBCA 1 Application	$6,900	$5,000	$11,900
2 Applications	$13,800	$10,000	$23,800
3 Applications	$20,700	$15,000	$35,700
4 Applications	$27,600	$20,000	$47,600
5 Applications	$34,500	$25,000	$59,500
6 Applications	$41,400	$30,000	$71,400
Full Source Treatment	$13,800	$50,400	$64,200

PHYSICAL PLACEMENT

Regenesis staff can assist in the details involving direct push or other small bore technology for emplacing ORC. Geoprobe or other hydraulic direct push equipment, small scale hollow-stem augers or hand augers provide an economic advantage over using full size hollow stem auger drill rigs.

Some applications are best delivered via an array of traditional cased wells that target the source; typically these would be four inch wells which would receive standard ORC filter socks. Sites with a small target zone are shallow and drilling costs modest.

ORC in powder form is typically slurried with water up to 66% solids wt/wt. Instructions for ORC/water slurry mixing are provided with each shipment and are available on our website at www.regenesis.com. The instructions can also be faxed or mailed upon request.

If a 2:1 ORC:water ratio is exceeded the material may not flow or pump properly. Thinner solutions can be made; however, a problem encountered may be getting less ORC per hole in proportion to the reduction in solids. All of the calculations in this document are predicated on 66% solids and can be adjusted proportionately.

On the other hand, thinner solutions, on the order of 35% to 60% solids can be injected under pressure into the formation. This may be ideal for delivering ORC into the pea gravel areas under tanks, in trenches, or to directly attack more heavily contaminated smear zones.

ORC as a slurry is essentially a grout-like material capable of hardening into a concretion of magnesium hydroxide. It has a very low permeability of 10^{-5} to 10^{-6} cm/sec. and can meet grouting standards, however, the ORC is not generally placed above the smear zone. Standard bentonite, concrete, or other approved materials are less expensive to complete a hole from the smear zone to the surface.

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