MONITORED NATURAL ATTENUATION:
IS IT APPROPRIATE? WHEN AND WHERE?

Natural attenuation generally describes a range of physical and biological processes which, unaided by deliberate human intervention, reduce the concentration, toxicity, or mobility of chemical or radioactive contaminants. These processes take place whether or not other active cleanup measures are in place. Increasingly, parties responsible for cleanup as well as environmental regulators are relying upon natural attenuation as a strategy for the remediation of hazardous waste in the subsurface environment. Yet there is no generally agreed upon approach for determining when and where natural attenuation is an appropriate remedy.

In November, 1997, U.S. EPA took a major step toward the establishment of such an approach. It published an Interim Final Policy, "Use of Monitored Natural Attenuation at Superfund, RCRA, and Underground Storage Tank Sites." This 20-page policy is designed to provide "guidance to EPA staff, to the public, and to the regulated community on how EPA intends to exercise its discretion in implementing national policy on the use of Monitored Natural Attenuation." Since the document was developed without much public input, EPA is now seeking broader comment before it "goes final."

This fact sheet uses EPA's interim policy as a framework for considering the various policy issues that may influence the acceptability of natural attenuation in the cleanup of hazardous substances. EPA's interim guidance addresses the natural attenuation of organic substances, such as fuels and chlorinated solvents, as well as inorganic contaminants, such as metals and radionuclides.

In its policy, EPA defines natural attenuation to include non-destructive mechanisms, such as dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, as well as the actual degradation of contaminants. However, it suggests that a reduction in concentration due to plume migration, in itself, is not likely to be acceptable. In fact, most technical experts believe that natural attenuation should be chosen as a remedy for organic contaminants only if significant amount of contaminant destruction is anticipated.

The advantages of natural attenuation include the reduced generation of remediation wastes, possible reductions in the cross-media transfer of contaminants, and lower remediation costs. The disadvantages include slower cleanups, the creation of transformation products that may be more toxic than the original contaminants, more costly site characterization, a reliance on uncertain institutional controls to ensure long-term protection, and the chance that subsurface conditions will not support natural attenuation as long as necessary.

The Burden of Proof

EPA puts the burden of proof on the party that proposes to select natural attenuation as a cleanup remedy. While natural attenuation in general has both advantages and disadvantages, the proponent must present convincing site-specific technical evidence that natural attenuation will effectively protect human health and the environment and furthermore, that it will achieve remedial objectives within a reasonable time frame. At sites where there are no evident exposure pathways -- for example, there is little or no demand for groundwater -- natural attenuation may be a realistic option.

In many common circumstances, however, natural attenuation is obviously **not** a desirable remedial alternative. These include sites where contamination poses an imminent risk to people or the environment or where a large plume shows no signs of stabilizing.

EPA has laid out three important principles for remedy selection, whether or not monitored natural attenuation is being considered as a possible remedial option. They apply no matter which statute provides cleanup authority, and no matter which regulatory office is responsible for oversight.

1. Source control actions should use treatment to address "principle threat" wastes wherever practicable. If treatment is not practicable, then the source should be contained with engineering controls. If natural attenuation is selected, it should only be selected after remedial options remove, treat, or contain the contaminant source.
2. Where practicable, groundwater should be brought to drinking water or similar standards within a reasonable time frame. Where restoration is not possible, further plume migration should be controlled **and** exposure pathways should be interrupted.
3. Soil should be remediated "to achieve an acceptable level of risk to human and environmental receptors," and the transfer of contaminants from one medium to another should not result in unacceptable levels of risk.

Evaluating Natural Attenuation

Consideration of monitored natural attenuation does not change or displace these remedy selection principles. In fact, it should be evaluated as a remedial option according to the National Contingency Plan (NCP). The NCP establishes the regulatory framework for hazardous waste sites that are regulated under the Resource Conservation and Recovery Act (RCRA) and sites that are regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, otherwise known as the Superfund). The NCP does not apply hard and fast formulas to remedy selection. Instead, supplemented by program guidance documents from EPA, it identifies factors -- effectiveness, feasibility, safety, cost, etc. -- that must be considered at each site in comparing possible cleanup strategies and technologies.

In the case of natural attenuation, EPA recommends that the proponent project, up front, whether contamination is likely to break down before it reaches (at hazardous levels) human or ecological receptors. That is, is the degradation into non-hazardous substances proceeding faster than the rate of migration? If contaminants have not yet reached receptors, and they are breaking down at a faster rate than they are traveling, natural attenuation may be appropriate.

While the answer to this question always depends upon the nature of the subsurface environment, different contaminants may respond differently under the same conditions. For example, fuel with benzene, toluene, ethylbenzene, and xylene (BTEX) usually does not sink as far as denser contaminants, such as chlorinated solvents. Because BTEX fuels remain just below the surface, which is generally more oxygenated, their breakdown is relatively rapid. Chlorinated solvents, which tend to sink to the bottom of the water table, tend to degrade more slowly.

Where stabilization -- of metals, for instance -- rather than degradation occurs, it means judging first whether the contamination is likely to be tied up before it reaches receptors and second, whether the stabilization process is likely to be permanent.

If contamination remains within property boundaries, controlling exposure pathways and minimizing risks to human health and the environment may be more manageable in the short run. However, because both land use and ownership may change -- even for large, seriously polluted federal facilities -- mere distance from property lines may not make natural attenuation more suitable in the long run.

Degradation, in itself, does not guarantee the protection of human health and the environment. Some degradation products are more harmful then the original contaminant. Vinyl chloride, for example, is more persistent, more mobile, and more toxic than its parent chlorinated compounds. In fact, it is a confirmed carcinogen (cancer-causing substance).

Furthermore, plumes may contain hazardous substances other than the principal contaminant of concern. For example, the gasoline additive methyl tertiary butyl ether (MTBE) has been found in a large number of fuel-contamination plumes. MTBE is resistant to biodegradation, and it migrates much faster than BTEX compounds.

Natural attenuation, therefore, must not only be demonstrated to be effective against the original contaminant of concern, but it must be capable of reducing the risk from degradation products and other contaminants.

Natural Attenuation in Conjunction with Active Responses

Even where and when natural attenuation is not likely, by itself, to meet cleanup goals, it may be acceptable as a supplement to active responses. In fact, since natural attenuation occurs regardless of regulatory approval, it is probably responsible for measurable reductions of concentration, toxicity, or mobility at even those sites with the most active remediation programs. In addition, active responses may be adopted as back-ups if natural attenuation proves inadequate. As a remedy, monitored natural attenuation may prove possible in conjunction with more active responses in four types of situations:

1. Outer portions of contaminant plumes where contaminant concentrations are very low might be left to natural attenuation while the rest of the plume is subjected to extensive treatment.

2. After active remediation has run its course -- that is, if monitoring shows that active remedies are no longer bringing significant or even measurable improvements -- then natural attenuation might be relied upon to finish the job.

3. Natural attenuation may be enhanced through the application of oxygen or other substances. Under certain conditions, simply adding oxygen to the soil or groundwater may dramatically speed biodegradation. Adding oxygen and methane to the subsurface environment may enhance cometabolism. And injecting chemical nutrients into the soil or groundwater may accelerate anaerobic degradation. One might question, however, whether "enhanced natural attenuation" is "natural" at all.

4. EPA recommends that when monitored natural attenuation is adopted as a remedy, a contingency remedy selection should also be made. That contingency would be implemented, without further consideration of remedial alternatives, if monitoring shows that natural attenuation fails to perform as anticipated. The contingency remedy should not only specify the alternate strategy; it should contain clear criteria for triggering its implementation. Those criteria should address trends in contaminant concentrations at specified locations, indications of new releases, indicators of renewed contaminant migration, rates of degradation relative to remediation objectives, and proposed changes in land use.

The EPA policy states that monitored natural attenuation is appropriate when it is protective of human health and is capable of achieving remediation goals "within a time frame that is reasonable" compared to other alternatives. However, the document states that the "reasonableness of the remediation time frame" should be evaluated on a site-specific basis. Factors include: the classification of the affected resource (e.g., is it a potential source of drinking water?); when the affected resource might be needed (including the availability of substitute resources); uncertainties regarding the quantity of contamination; and the reliability of monitoring and institutional controls over a long period.

Even when natural attenuation compares favorably to conventional remedial strategies, such as pump-and-treat, it may also be necessary to consider innovative alternatives. Otherwise, over-reliance on natural attenuation could stifle the development of new cleanup technologies. Many of today's remedies accomplish cleanup tasks that were "impossible," or at least not feasible, when cleanup laws and standards were originally promulgated. If the sites where these remedies were proven had defaulted to natural attenuation, these technologies would not be available. If natural attenuation is selected as the remedial strategy, it therefore may make sense to review this strategy periodically to ensure that new technologies are not being overlooked.

Monitoring

The word "Monitoring" in EPA's policy demonstrates, as far as regulators are concerned, that natural attenuation does not mean that responsible parties can simply walk away from contamination sites. Just as they must demonstrate, in advance, that natural attenuation is likely to protect public health and the environment, they must show, after approval, that it's working as advertised.

EPA recommends, in its policy, that monitoring be designed to accomplish the following:

- Identify potentially toxic transformation products.
- Determine if the plume is expanding either laterally and vertically.
- Ensure that there is no effect on downstream receptors.
- Detect any new releases that could effect the remedy. Detect changes in hydrogeological, geochemical, or microbiological parameters that might reduce the effectiveness of natural attenuation. While EPA's Monitored Natural Attenuation guidance lists several factors that should be considered in monitoring performance, it does not explicitly require monitoring to prove that attenuation is due to biological activity, nor does it specify what level of certainty is adequate to verify that natural attenuation is occurring.

In summary, not only is EPA's policy on natural attenuation still essentially in draft form, but even if it's adopted as is, affected communities -- if attentive, informed, and organized -- will have ample opportunity to question the selection of monitored natural attenuation as a remedy.

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