GAINING REGULATOR ACCEPTANCE OF NATURAL ATTENUATION AS A REMEDIATION TOOL

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ABSTRACT

Monitored natural attenuation (MNA) makes use of biological degradation, chemical reactions with natural materials, and other processes to clean up contaminated soils and groundwater. In the past, the regulatory community has been slow to accept natural attenuation due to a misperception that natural attenuation is a "do nothing" approach. Recently however, regulators have been more open to considering MNA as part of an overall clean-up plan that includes active treatment technologies to remove or contain the source of contamination at a site.

MNA is currently being implemented at the Savannah River Site for remediation of selected contaminants. The South Carolina Department of Health and Environmental Control, who has regulatory authority over these actions, has accepted this process. Significant overall cost savings are forecast. Additionally, there will be less disruption to the ecosystem, compared with engineered technologies.

This paper describes the monitored natural attenuation concept as well as the process of constructive engagement with the regulators to achieve acceptance. Application to DOE, DOD, and commercial sites, as well as acceptability to other regulatory bodies, will be discussed with an emphasis on strategies to prevent false starts in the negotiation process and inventing options that result in mutual gains for all parties.

THE NATURAL ATTENUATION CONCEPT

Simply put, natural attenuation makes use of natural processes to contain the spread of contamination and reduce the concentration and amount of pollutants at contaminated sites. It is also referred to as intrinsic remediation, bioattenuation, or intrinsic bioremediation and is an *in situ* treatment method. That is, environmental contaminants are left in place while natural attenuation works on them. At the beginning of the past decade the focus was primarily on microbial effects; the innate capabilities of naturally occurring microbes to enhance degradation of certain chemicals.

In this process, naturally occurring microorganisms (yeast, fungi, or bacteria) break down, or degrade, hazardous substances into less toxic or nontoxic substances. Microorganisms, like humans, eat and digest organic substances for nutrition and energy. Certain microorganisms can digest organic substances such as fuels or solvents. Biodegradation can occur in the presence of oxygen or without oxygen. In most subsurface environments, both aerobic and anaerobic biodegradation of contaminants occurs. The microorganisms break down the organic contaminants into harmless products; mainly carbon dioxide and water in the case of aerobic biodegradation. This is depicted schematically in Figure 1. Once the contaminants are degraded, the microorganism populations decline because they have used their food sources.

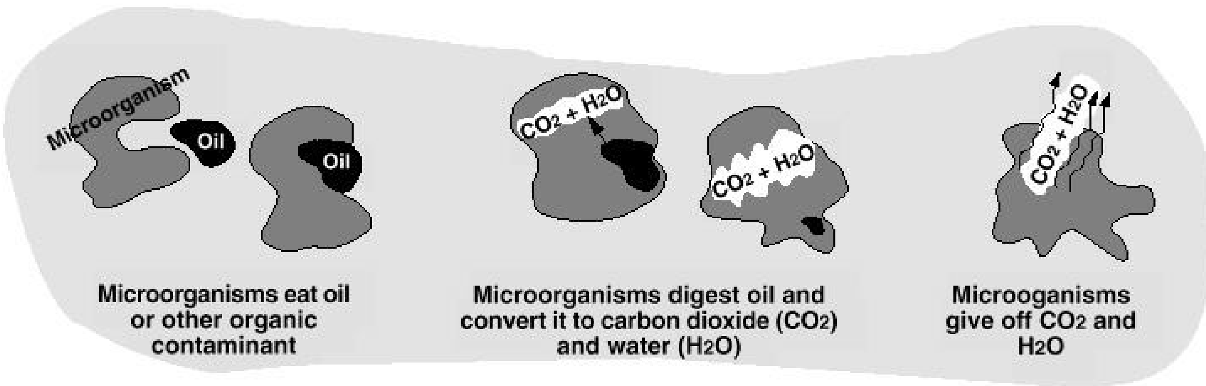

Fig. 1. Generalized natural attenuation process

Organic contaminants vary widely in their susceptibility to transformation by microorganisms. Some contaminants are highly biodegradable, while others resist degradation. In general, the more degradable contaminants have simple molecular structures and are water soluble. Organic contaminants that resist biodegradation usually have complex molecular structures, low water solubility or an inability to support microbial growth.

Two classes of biodegradation reactions are aerobic and anaerobic. Aerobic biodegradation involves the use of molecular oxygen (O_2), where O_2 receives electrons transferred from an organic contaminant:

$$\text{organic substrate} + O_2 \rightarrow \text{biomass} + CO_2 + H_2O + \text{other inorganics}$$

The organic substrate is oxidized and the O_2 is reduced to water. The organic substrate serves as the source of cell carbon used to build microbial cells (biomass). Other microorganisms oxidize reduced inorganic compounds (NH , Fe , or H S) to gain energy and fix CO_2 to build cell carbon in a similar fashion.

Halogenated compounds can also be used as growth substrates or co-metabolized by aerobic and anaerobic microorganisms. Halogenated compounds can often serve as the electron acceptor and become reduced in environments where there is a source of electrons; for example, where methane is present.

Petroleum hydrocarbons are a highly varied class of naturally occurring chemicals used as fuels in a variety of industrial and commercial processes. Biodegradation potential varies depending on the type of hydrocarbon. Benzene, toluene, ethylbenzene, and xylene are components of gasoline and are collectively denoted as BTEX. These chemicals are easily biodegraded to carbon dioxide by aerobic microorganisms. Under ideal conditions, microbes can degrade all of the BTEX components within the aerobic zones of a contaminated site. Largely for this reason, they were the first class of compounds considered for remediation using natural attenuation. Currently natural attenuation is the leading remedy for more than 15,000 sites where gasoline or other fuels have leaked from underground storage tanks.

NATURAL ATTENUATION AS A REMEDIATION TOOL

When natural attenuation is proposed as a remedy for site clean up it is called monitored natural attenuation (MNA). The EPA (1) defines monitored natural attenuation as "the use of natural attenuation processes within the context of a carefully controlled and monitored site cleanup approach that will reduce contaminant concentrations to levels that are protective of human health and the environment within a reasonable time frame." Further, the EPA cites the monitored natural attenuation processes as being "those processes that degrade contaminants and expects that MNA will be most appropriate where plumes are stable and dilute. This is illustrated schematically in Figure 2.

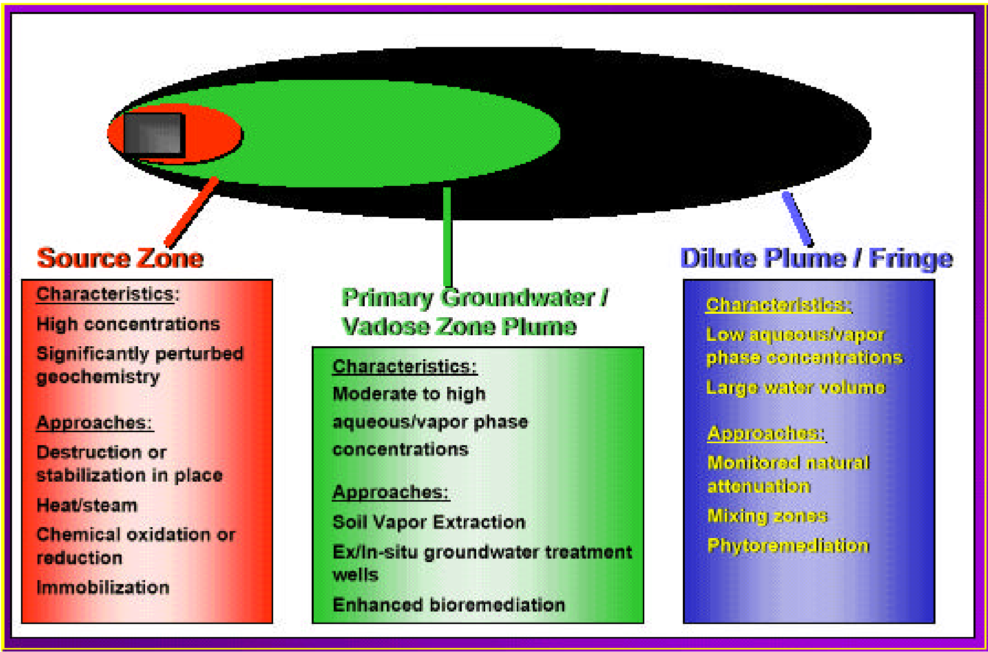

Fig. 2. Natural Attenuation applied as a remediation tool.

As shown in Figure 3., use of natural attenuation as a formally documented remedy has become increasingly common in all of the U. S. Regulatory programs for the cleanup of contaminated sites (2).

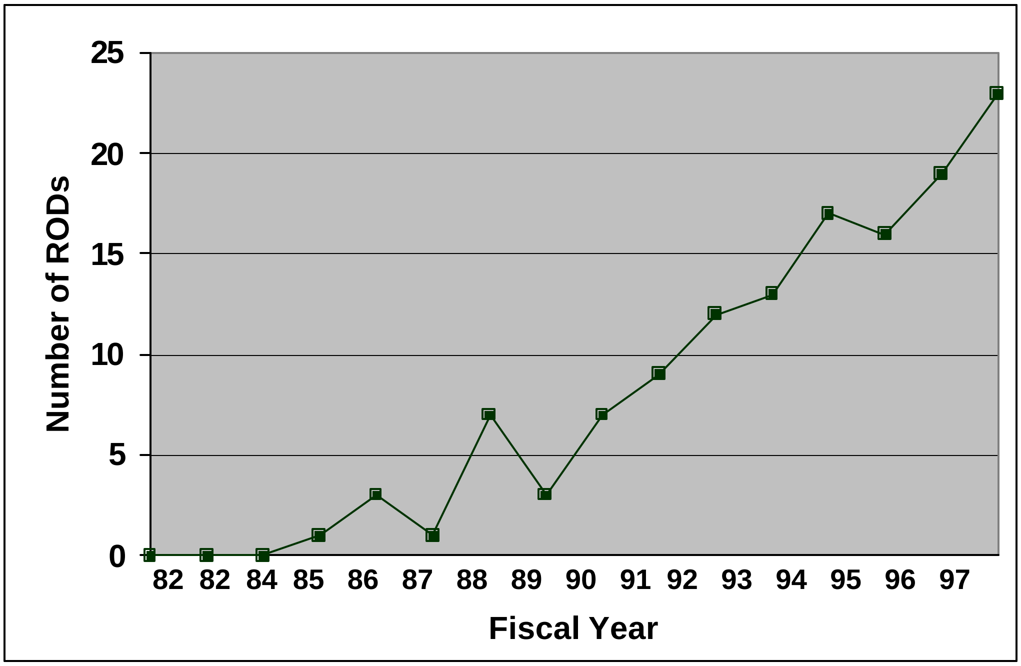

Fig. 3. Records of decision (ROD's) with MNA as a proposed remedy

In the past four years there has been tremendous increase in MNA research and active implementation as a cleanup remedy. The Environmental Protection Agency (EPA) and state level counterparts are receiving an increasing number of proposals to use MNA in place of or in conjunction with engineered systems for a wide variety of contaminants, including chlorinated organic chemicals, explosives, metals, and radionuclides, in addition to gasoline and other fuels. All ten EPA regions have sites with MNA being implemented and most states now have specific protocols or guidelines of their own. Essentially all of the Federal agencies with landlord responsibilities, such as the Department of Defense and Department of Energy have vigorous scientific programs that have developed numerous protocols for assessing applicability and use of MNA. Likewise, corporations and professional associations have also developed technical Guidelines. Some of these are shown in Table 1.

Table I. Natural Attenuation Protocols

Environmental Protection Agency	"Use of Monitored Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites," Final OSWER Directive (OSWER Directive Number 9200. 4-17P), April 21, 1999, EPA Office of Solid Waste and Emergency Response.
Environmental Protection Agency	"Draft Region 4 Suggested Practices for Evaluation of a Site for Natural Attenuation (Biological Degradation) Of Chlorinated Solvents," Version 3.1, November 1999, EPA Region 4.
Department of Energy	"Site Screening and Technical Guidance for Monitored Natural Attenuation at DOE Sites," Draft, August 30, 1998 Sandia National Laboratory
Air Force	"Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination in Groundwater," Volume I and II. Air Force Center for Environmental Excellence, Technology Transfer Division, Brooks AFB.
Air Force	"Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater," July 1997, Air Force Center for Environmental Excellence, Technology Transfer Division, Brooks AFB.
Navy	"Technical Guidelines for Evaluating Monitored Natural Attenuation at Naval and Marine Corps Facilities," Wiedemeier and Chapelle Draft Revision 2, March 1998.
New Hampshire Department of Environmental Services	"Guidelines for Selection of Natural Attenuation of for Groundwater Restoration," New Hampshire Department of Environmental Services, October 1999.
South Carolina Department of Health and Environmental Control	"Groundwater Mixing Zone Application Guidance," SCDHEC, May 1, 1997
Chevron	"Protocol for Monitoring Intrinsic Bioremediation in Ground Water", Buscheck and O'Reilly, March 1995, Chevron Research and Development Company, Health Environment and Safety Group.
American Society for Testing and Materials	'Standard Guide for Remediation of Groundwater by Natural Attenuation at Petroleum Release Sites," Draft, February 1997.
American Petroleum Institute	"Methods for Measuring Indicators of Intrinsic Bioremediation: Guidance Manual," American Petroleum Institute, Health and Environmental Sciences Department, Publication number 4658, November 1997.

As the past decade closed, many regulators were happy to be closing the books on sites by accepting MNA as a remedy. Parties that were responsible for site cleanup were also relieved to have an approach that seemed to save time and capital expenditures. The types of sites and contaminants for which MNA was being considered was growing steadily: petroleum hydrocarbons, chlorinated solvents, heavy metals, radionuclides and more.

However, not everyone was pleased with the rapidly expanding use of MNA as a remedy. At sites where communities are aware of groundwater contamination, community representatives often expressed significant reservations about using MNA as a cleanup remedy. They wanted sites cleaned up as soon as possible. Although engineered cleanup systems can leave contamination in place for a long time due to technical complexities, community members often perceived MNA as unlike engineered systems because the method does not use **visible** contaminant treatment. Stakeholders were more willing; however, to accept MNA if responsible parties and regulators could provide evidence that the natural processes operating could transform contaminants to harmless byproducts. Currently, opportunities for public involvement in decision making are limited at most sites. The public is usually is not invited to comment until after those responsible for the contamination and the environmental regulators have completed their site investigations and identified candidate remedies. As a consequence, the public may mistrust the choices outlined by the responsible parties, and, ultimately the remedy selected by the regulatory agency. At this stage, public outcry can lead to delays in the remediation process. Although involving the public (and in most cases the regulators) early may slow the initial stages of remedy selection, it prevents costly false starts and in the long run reduces delays.

Finally, since MNA is a new and somewhat abstract technology to the layman, it is critical that involvement of the public and regulatory agencies utilize a different approach than most of the scientific and engineering community is used to. New challenges in communication and technology education will be encountered and need to be diligently addressed. The next sections of this paper identify the obstacles that need to be overcome if success is to be achieved in having the public and regulators accept MNA as an appropriate remediation tool.

KEYS TO REGULATOR ACCEPTANCE

Communicating to Stakeholders and Regulators as a Scientist –Traditional Problems

Regulatory agencies responsible for approving remediation remedies must take into account two things as they go through the internal decision process. First, what is their own interpretation and understanding of regulations, and second what is the opinion of the public and stakeholders likely to be. For implementation of new or innovative technologies, such as MNA, these two aspects are greatly influenced by the scientific communication of subject matter experts. The first obstacle to address lies here.

Scientists are trained to present work to other scientists in the form of journal articles, books, or live presentations. Discussions and debates about scientific work are conducted in a "scholarly" manner, for example by questioning assumptions, inquiring about the study design and data collection methods, criticizing the analytical methods, and debating whether or not the data support the conclusions drawn by the author or presenter. Questions are answered and criticisms rebutted using appropriate scientific terminology.

Scientific communication has been conditioned by certain professional values and practices:

- The importance of the scientific method in reaching conclusions—if not tested and retested, then things are not certain
- Division of science into disciplines, each with its own special vocabulary and procedures
- Knowledge derived from science as, in itself, morally neutral
- The belief in scientifically acquired knowledge as a foundation to improve human health and welfare and the environment

- The separation of information (factual and testable knowledge) from persuasion

- The view that complex information is essentially non-convertible—that is, it must be "dumbed down" to be paraphrased or explained

- The belief that scientific information is the most important thing that a scientist can communicate.

However, stakeholders and some regulators, may not share the above beliefs. As a result, they understand science to varying degrees and have a multitude of different frames of reference about the worth of scientific information. The presentation and questioning techniques that scientists have been taught, and that work so well when communicating with other scientists, are simply not adequate to address technical dialog with the regulators and stakeholders. When scientists rely only on professional techniques to communicate science and basic research to these audiences, two outcomes often result that open up a chasm between the scientist and other meeting participants.

First, the scientists feel "besieged" by a barrage of questions that appear to be trivial, irrelevant, or unanswerable. Believing that they are victims of a mismanaged process, they avoid further interactions, particularly with non-scientists. Second, other meeting participants feel that the scientists have not adequately answered their questions, which, after all, were asked in good faith. Believing that the scientists have not been responsive, they begin to question the scientists' motives and integrity. When all is said the communities and stakeholders remain skeptical.

How does all of this apply to MNA? In a recent report (3) the National Research Council summarized the nationwide community concerns surrounding natural attenuation. Table 2 shows these in abbreviated form.

Table II. Specific Community Concerns About Natural Attenuation

It represents a "do-nothing" approach	No standard documentation methods exist
The plume may expand	It legitimizes dilution
Evidence is often insufficient	A scientific basis is lacking
Monitoring requirements are insufficient	Effects on mixtures are uncertain
Hazardous by-products may form	Time line may be long
Institutional controls are inadequate	Funding for contingency plans are inadequate

Achieving the Desired Outcome

Given the above dilemma, the Savannah River Site (SRS) undertook a new strategy to communicate with the public and negotiate with the regulators on matters concerning the use of MNA as a remediation tool. This strategy borrows heavily from techniques developed at the Harvard Negotiation project (4, 5) and focuses on deciding issues on their merits rather than through a haggling process focused on what each side says it will and won't do. A formal "workshop" process was developed at SRS and those managers, scientists, and engineers who would be principals in the negotiation process attended the training. This training came to be informally known as the "Achieving the Desired Outcome" course.

The basic elements of the negotiating strategy implemented at SRS are summarized below.

Arguing over positions produces unwise arguments- avoid this

The more a negotiator clarifies his position and defends it against attack, the more committed he becomes to it. The more you try to convince the other side of the impossibility of changing your opening position, the more difficult it becomes to do so. You ego becomes identified with you position.

Arguing over positions endangers an ongoing relationship – avoid this

Positional bargaining eventually becomes a contest of will. Each negotiator asserts what he will and won't do. The task of devising an acceptable solution soon becomes a battle. Anger and resentment result. The relationship is strained as one side sees itself bending to the rigid will of the other.

When there are many parties, positional bargaining is even worse

As is often the case when negotiating environmental topics, several parties may be at the table. Each may have constituents, higher-up, or boards–of-directors with whom they must deal. Usually these groups have painfully developed and agreed upon a position in advance so it becomes much harder to change it.

For a wise solution reconcile interests, not positions

The basic problem in negotiations lies not in conflicting positions, but in the conflict between each side's needs, desires, concerns and fears. When negotiators look behind opposed positions for the motivating interests, they often find an alternative position which not only meets your interests but theirs as well.

Look Forward, not back

Instead of arguing with the other side about the past, talk about what you mutually want to have happen in the future. Ask, " If the other side agrees to go along with me, what do I think I would like them to go along with?"

Invent options for mutual gain

Separate the act of inventing options from the act of judging them. Broaden the options on the table rather than looking for a single answer.

Broaden the options

Multiply options by shuttling between the specific and the general. Look through the eyes of different experts. Invent agreements of different strengths.

Make the decision easy

Confront the other side with a choice that is as painless as possible. Advance your case by taking care of interests on the other side.

Insist on using objective criteria

Develop alternative criteria before and hand think through their application to your case. Use the principle of "one cuts, the other chooses".

RESULTS AND CONCLUSIONS

Using the negotiating techniques outlined above, SRS has been successful in gaining regulator approval to use MNA as the remedy for three major environmental restoration projects: the D-Area Oil & Seepage Basin, the old F-Area Basin, and the C-Area Burning/Rubble Pit. Based on these successes, 3 additional project plans utilizing MNA as the remedy have been submitted to the South Carolina Department of Health and Environmental Control for approval. Other potential candidate sites at SRS for MNA are currently being evaluated for future proposals.

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(5) Gerry Spence, *How to Argue and Win Every Time*, (New York: St. Martin's Press, 1995).

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