Application of Natural Attenuation Processes to Remediate Metals and Radionuclides in Groundwater: Regulatory Guidance and Stakeholder Perspective

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ABSTRACT

Many sites across the United States have groundwater contaminated with metals or radionuclides - often at low levels, but above standards. Most potential engineered remedies are too costly or otherwise impracticable. In contrast, attenuation-based remedies rely on natural processes to sequester the contaminants of concern and are therefore less aggressive and invasive, and are typically less costly. While attenuation of organic contaminants is being increasingly accepted as a remedy, attenuation of metals and radionuclides involves more complicated or interdependent sets of processes and has rarely been applied. Because technical guidance specifically addressing the use of attenuation-based remedies for metals and radionuclides has only recently been available, the application of attenuation remedies for metals and radionuclides has been inconsistent.

In order to facilitate the acceptance of attenuation-based remedies for metals and radionuclides, the Interstate Technology and Regulatory Council (ITRC) has developed a technical and regulatory guidance document, which builds upon the Environmental Protections Agency (EPA)'s new technical framework documents and emerging policy directive. The guidance includes recommendations for evaluating and documenting attenuation-based remedies in a consistent and technically defensible manner. A decision framework flowchart guides users through a stepwise series of decisions that help determine if relying on attenuation processes is feasible and can lead to successful implementation.

To determine the specific approach of this document, ITRC conducted a web-based survey of state regulators and stakeholders to determine the existing state of knowledge and acceptance regarding the application of attenuation processes as a remedy. Stakeholders may be concerned that attenuation-based restoration of radionuclide and metal contamination may require a more detailed characterization of the site or that attenuation will require extensive long-term monitoring to ensure public health and ecological parameters are met. Attenuation, perhaps more than other environmental restoration techniques for metals and radionuclides, depends strongly on balancing relationships between the contaminated media and the geochemistry at a specific site during a specific period of time - a dynamic stasis of sorts. Significant uncertainties in attenuation cleanup efficacy and timelines may conflict with stakeholder expectations. Communities generally do not favor prolonged cleanup approaches with uncertain funding, with a commensurate degree of risk, and a shift of the burden for environmental cleanup to another generation. As such, contaminant removal through conventional means (e.g., pump and treat) might be preferred, unless it can be demonstrated that attenuation can be equally protective of public health and the environment with an added cost-benefit.

INTRODUCTION:

The EPA defines natural attenuation (MNA) as "reliance on processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a timeframe that is reasonable compared to that offered by other more active methods. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants" .

Integration of attenuation-based technologies into the remediation of metals and radionuclides contamination might become a complex undertaking at many sites. While attenuation of organic compounds is predominantly based on biotic processes, attenuation of metal and radionuclide contaminants is predominantly based on abiotic processes. For metal and radionuclide contaminants in the subsurface, the interaction with the soils and sediments become very important because in large part, the properties of the soils and sediments will strongly control the attenuation processes. Until recently, there has been little regulatory guidance to support attenuation–based remedies for groundwater contaminated with radionuclides and metals. This has contributed to inconsistent application of those remedies and generally discouraged their consideration. The net result is that many sites face intractable closure problems. The Attenuation Process for the Metals and Radionuclides (APMR) team of Interstate Technology and Regulatory Council (ITRC) is developing technical and regulatory guidance to facilitate implementation of the new EPA guidance for MNA of metals and radionuclides. This framework will provide a consistent basis for states, stakeholders, federal agencies, and site owners to evaluate and implement attenuation-based remedies. The outcome of the efforts is a process that will encourage regulatory cooperation and expedite cleanup

REGULATORY POLICIES AND REALATED GUIDANCE

According to the National Research Council (NRC) report of 2000 [1] "natural attenuation is an established remedy for only a few types of contaminants," which does not include metals and radionuclides. This is still largely true, because MNA of metals and radionuclides was not considered an available remedy when many of the current regulations were written. However, federal and state regulations and guidance are now beginning to include some provisions pertinent to utilizing MNA for metals and radionuclides. The section highlights current regulatory positions of federal and state regulatory agencies.

Federal Policy and Guidance

In 1980, Congress passed Public Law 96-510, also known as the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [**2].** This act and subsequent reauthorization acts in 1986 and 1990 (i.e., Superfund Amendments and Reauthorization Act of 1986 [SARA] and the Omnibus Budget Reconciliation Act), provided statutory requirements for remediation of sites where hazardous substances have been released into the environment. All remedial actions at CERCLA sites must be protective of human health and the environment and comply with applicable or relevant and appropriate requirements (ARARs) unless a waiver is

justified. Cleanup levels for response actions under CERCLA are developed based on site-specific risk assessments and/or ARARs. EPA expects to return usable ground waters to their beneficial uses whenever practicable.

The EPA's Office of Solid Waste and Emergency Response (OSWER).Directive of 1999 **[3]** goes on to state a preference for those processes, including biodegradation, dispersion, dilution, sorption, volatilization, radioactive decay, and chemical/biological stabilization, transformation or destruction of contaminants, that permanently degrade or destroy contaminants, and for use of MNA for stable or shrinking plumes. The directive also provides a few general guidelines for use of MNA as a remedial approach for inorganic contaminants. The key policy concerns are that the specific mechanisms responsible for attenuation of inorganic contaminants should be known to be occurring at a particular site, and the stability of the process should be evaluated and shown to be protective under anticipated changes in site conditions. The 1999 OSWER Directive provides the context for EPA's expectations for evaluating the feasibility of employing MNA as part of a cleanup remedy for contaminated ground water. Different federal and state remedial programs may have somewhat different remedial objectives. The "*Attenuation Remedies at Department of Energy Sites*" **[4, 5]** provides a decision-making framework for evaluating the efficacy of MNA as a remedial alternative consistent with applicable regulations and the EPA's OSWER Directive 9200.4-17P. USDOE Guides are not requirements documents and are not to be construed as requirements. They provide information that may be useful in implementing a specific DOE order. In 2007, the EPA published the first two of a three volume series called "Monitored Natural Attenuation of Inorganic Contaminants in Ground Water" (EPA, 2007a; EPA, 2007b**) [6, 7].** This trilogy represents a technical resource for site managers to facilitate evaluation for the potential effectiveness of monitored natural attenuation (MNA) as a remedial approach for metals and radionuclides in ground water. The third volume (scheduled for publication in 2009), titled "Assessment for Radionuclides Including Americium, Cesium, Iodine, Neptunium, Plutonium, Radium, Radon, Technetium, Thorium, Tritium, Strontium, and Uranium," consists of individual chapters that describe 1) the natural processes that may result in the attenuation of the listed contaminants and 2) data requirements to be met during site characterization. Emphasis is placed on characterization of immobilization and/or degradation processes that may control contaminant attenuation, as well as technical approaches to asses.

In addition to the three volume series briefly described above, two additional references describing processes of MNA for metals are available: (1) Technical Resource Document for Monitored Natural Recovery of Contaminated Sediments developed by the EPA's office of Research and Development (EPA-ORD**) [8]** and (2) Development of Guidance for Monitored Natural Recovery at Contaminated Sediment Sites (Department of Defense). These two documents discuss technical aspects of natural attenuation of metals specifically applied to sediments; however, the geochemical processes which apply to metals sequestration and mobilization in sediments are also directly applicable to groundwater a Department of defense (DoD) guidance document issued through the Environmental Security Technology Certification Program (ESTCP).These two documents discuss technical aspects of natural attenuation of metals specifically applied to sediments; however, the geochemical processes which apply to metals sequestration and mobilization in sediments are also directly applicable to groundwater.

State Policies and Guidance

In RCRA-authorized states, the RCRA-equivalent state regulations can be considered ARARs under CERCLA or may be applied directly. MNA of metals and radionuclides was not considered an available remedy when many of the current state regulations were written. In some cases, however, MNA seems to fit the intent of the existing regulations even if it is not specifically mentioned as a remedy.

A "consensus report" on the use of bioremediation for radionuclides and metals contamination. Was produced by a working group consisting of 11 regulators from 8 states that was organized by Oregon State University in 2005 **[9]**. State regulators on the APMR team also added their perspectives. The report includes a list of factors/criteria /factors that could be used as requirements in determining acceptability of the remediation. The importance of each factor will depend on site-specific environmental conditions, hydrogeology, land ownership and current regulatory requirements. In general, in order for MNA to be considered as a remedial option, regulators must have confidence in the technology prior to full-scale application.

STAKEHOLDERS PERSPECTIVE

Stakeholders include people in communities living near contaminated facilities, Site-Specific Advisory Boards, Tribal Governments, local governments, and a variety of non-governmental organizations. The section highlights major concerns related to restoration by attenuation in general.

Survey

The Attenuation Processes for Metals and Radionuclides (APMR) Team of ITRC conducted a web-based survey of state regulators and stakeholders to determine the existing state of knowledge and acceptance regarding the application of attenuation processes as a remedy at sites with groundwater contaminated with metals and/or radionuclides. Results of the survey found that there appears to be a lack of knowledge with respect to the technical and regulatory aspects of attenuation for radionuclides. Further, responses to the survey suggested a greater level of uncertainty in understanding the importance of the various attenuation mechanisms associated with radionuclides than those associated with metals. However, respondents appeared comfortable with their knowledge associated with attenuation of metals and the importance of the various attenuation mechanisms. Survey findings also indicated a lack of governing policies and guidelines for evaluating the viability of attenuation based remedies for sites with metals and/or radionuclide contamination.

The team also solicited information regarding how policies in various states apply MNA as a remedy. Regulators in 24 states responded. It was found that many allow MNA as a remedial option for organic as well as for metals and radionuclides. Details of this survey will be published by the team in 2010.

Stakeholders Issues

There is no "one-size-fits-all" method for addressing issues raised by stakeholders representing different groups. For example, the Tribes are different than public stakeholder groups in that Tribes enjoy government-to-government relations with Federal, state and local governments and must be accorded this status. Each tribe is a unique entity culturally, governmentally, and socially. There is no overarching "Native American" view or policy on natural attenuation. Some tribes view any level of contamination of their land and natural and cultural resources as a grave insult. Many (if not all) tribes will have areas that are culturally significant and even sacred. In situations that concern culturally significant/sacred areas, rules that non-tribal environmental professionals rely on may be superseded. As to risk assessment, tribal pathways and life ways are unique and different from the dominant culture, and tribal uses of natural materials are unique. Tribal risk assessment does not follow traditional models. Much of the pathway and exposure information may be proprietary and may not be shared beyond the tribe

Stakeholders may be concerned that attenuation-based restoration of radionuclide and metal contamination may require a more detailed characterization of the site or that attenuation will require extensive long-term monitoring to ensure public health and ecological parameters are met. Attenuation, perhaps more than other environmental restoration techniques for metals and radionuclides, depends strongly on balancing relationships between the contaminated media and the geochemistry at a specific site - a dynamic stasis of sorts. Significant uncertainties in attenuation cleanup efficacy and timelines may conflict with stakeholder expectations. As such, stakeholders should receive additional communication of technical information, results of monitoring and prognoses.

Communities generally do not favor prolonged cleanup approaches with uncertain funding, with a commensurate degree of risk, and a shift of the burden for environmental cleanup to another generation. As such, contaminant removal through conventional means (e.g., pump and treat) might be preferred, unless it can be demonstrated that attenuation may produce an equal protection of the public health and the environment with an added cost-benefit.

The public should be full partners in future land-use decisions. Generally, the public favors site cleanup that leads to unrestricted use. Depending on the site-specific characteristics, attenuation based restoration may require restricted access and/or institutional controls for a long period of time while the restoration proceeds. If not possible, the smallest area possible should be set aside, and institutional and engineering controls should be incorporated into the activity. These should include surveillance and monitoring system, and permanent markers should be developed for contaminated sites. If land use does lead to unrestricted use, a long-term stewardship program must be developed to ensure that the contaminants are reduced to acceptable levels or eliminated. If attenuation is selected, the site should be properly memorialized for long-term identification.

During attenuation, the general public's exposure to contaminants should be negligible. Worker health and safety should also be positively affected. A related stakeholder concern is that the strictest cleanup standards be applied. Cleanup standards may differ from site to site based on risk assessments, site conditions, or state regulations; however, communities generally want to see the strictest standard that has previously been applied nationally. Communities often ask for

clean-up standards that result in risk levels below 10-6 (i.e., no excess cancer risks greater than one in one million).

CONCLUSIONS

As stated in the National Research Council report (NRC 2000), "natural attenuation is an established remedy for only a few types of contaminants," which does not include metals and radionuclides. This is still largely true, because MNA of metals and radionuclides was not considered an available remedy when many of the current regulations were written. However, federal and state regulations and guidance are now beginning to include some provisions pertinent to utilizing MNA In order to facilitate the acceptance of attenuation-based remedies for metals and radionuclides; well defined regulatory approach needs to be developed. The acceptable regulatory path should address stakeholders concerns and issues.

REFERENCE

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