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Title: BARRIERS AND POST-CLOSURE MONITORING (AL121125)

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MASTER

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Technology Information Profile (rev. 2) for ProTech
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1. Technical Name of Technology: Barriers and Post-Closure Monitoring

2. Common Name of Technology: Barriers and Monitoring

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4. Affiliation: EES-15, Los Alamos National Laboratory; INC-15, Los Alamos National Laboratory

5. Technology Category: Containment / Disposal

6. Developers: Los Alamos National Laboratory

7. Application

7.1. Where (in-situ/ex-situ): In Situ
7.2. Media: Arid Soils
7.3. Targeted Contaminants: Metals (especially those which are soluble), Organics

8. Scope of project (feasibility study, treatability, bench, pilot, field):
Field

9. Integrated Demonstration (ID) Need/Requirements:
Site closure and post-closure monitoring are regulatory requirements under RCRA, CERCLA, SARA, and DOE Order 5820.2A. Regulations with respect to the discharge and monitoring of toxic (organic and inorganic chemicals) and radioactive mixed wastes will become increasingly stringent. However, cost-effective, environmentally benign solutions have been elusive.

10. Objective

10.1. Objective of technology (e.g., This technology will destroy VOCs in groundwater.):
This project supports the DOE RDDT&E plan in Environmental Restoration and Waste Management activities and focuses on the rapid implementation of near-surface barriers, biotreatment, and post-closure monitoring technology. It uses water-permeable and biologic barriers that chemically capture and/or degrade contaminants without significantly altering the natural water flow regime. It also employs technology previously developed by the petroleum / chemical / engineering industry and the Departments of Energy and Defense: specifically, the integration of gel barrier materials, enhancement of natural biologic communities, chemical tracer approaches, reservoir management technology, and remote monitoring of the hydrologic systems. Barrier approaches are being tested for two different applications. The first is the use of barriers for confinement of chemical contaminants for in-trench treatments with leach systems or an in-place bioreactor. The second is an enhancement of the current practice of emplacing grout or clay slurry walls into direct horizontal surface and subsurface water flows around a contaminated area by integrating permeable reactive barriers and petroleum reservoir gel/foam/polymer technology.

10.2. Baseline (baseline technology to which it is compared):
Traditional Caps and Monitoring Wells (Caps and Wells)

11. Process Description:
Two types of barriers have been the focus of initial efforts of this program: (1)Permeable, Reactive Barriers: In many instances a barrier can be used that allows for the passage of water while prohibiting the movement of contaminants. These barriers employ such agents as chelators (ligands) selected for their specificity for certain metals, sorbents, and microbes, among others. In DOE sites where multiple contaminants are ubiquitous, multicomponent barriers need to be evaluated for their ability to extract contaminants, while remaining stable for relatively long periods of time. Reactive barriers could be designed to remain in place as permanent or semi-permanent barriers, to be removed and replaced periodically (and thus serve as a component of the remediation process), and/or to be used as part of the post-closure monitoring system (i.e., the appearance of a contaminant in a reactive barrier could serve to warn of impending contaminant migration).

Post-closure monitoring of the field experiments has focused on evaluation of water saturation and chemical transport. Established neutron probe measurements are being compared to TDR (Time Domain Reflectometry) probe measurements to evaluate opportunities for automated and more detailed characterization. Chemical transport is being observed through the use of contaminant and chemical tracer materials at low concentration levels. Application of tagged tracers allows evaluation of both barrier system effectiveness and potential contaminant transport pathways or eminent arrival.

11.1. Input:
Field scale experiments were constructed using natural sand. Existing hydrologically permeable barriers include zeolite+silica gel+sand, bentonite+Al-cross linked polyacrylimide+sand, and peat+Al-cross linked polyacrylimide+sand. Tracer/psuedo-contaminant suites for the permeable barrier experiments include common anions (e.g. bromide), soluble organic acids, semi-volatile organic acids, fluorescein, chromium, and EDTA, all at low concentrations. Bio-barrier experiments also include sections of natural soil and plant communities. Tracer/psuedo-contaminant for the bio-barrier experiments is presently focused on toluene, labeled with carbon-13 to allow specific characterization of transport and biodegredation processes as a function of plant cover and fertilization.

11.2. Output:
The input chemicals diluted in water and samples of the barrier systems will be the physical products of these experiments. Data output will be tracer concentrations as a function of time and physical conditions of the systems.

12. Summary of Technology Advantages (relative to the baseline: faster, better, cheaper, safer):
Barriers and post-closure monitoring will allow containment of sites not amenable to the baseline technologies. Screening technologies are essential for compliance with increasingly stringent effluent requirements and for cost reductions in site operations. Integrated evaluation of hydrologic and reactive barrier technology, in situ biodegradation and post-closure monitoring provide essential information required for defining and implementing applications of in situ remediation, enhanced closure systems, and long term monitoring. Decreased operational expenses and significantly enhanced community confidence in site operations are particularly significant for public and regulatory acceptance of in situ remediation and/or site containment as other remediation approaches are defined and implemented.

Many potential environmental barrier materials, including grouts, have the disadvantage of cracking with age, usually due to plant invasion, wet/dry cycles and freezing/thawing cycles. Clay slurries will eventually dry in near surface environments and produce cracks. Experiments using slurried bentonite have shown that the combination of an arid climate and plant invasion results in water loss from the slurry with subsequent cracking and water flow. In addition, purely hydrologic barriers (grouts, clay slurries and cements) by design restrict water transport out of the contained area and often require active treatment and disposal systems to maintain a stable system.

13. Limitations of Technology (relative to the baseline: faster, better, cheaper, safer):
Enhanced barrier technologies (polymer or gel augmented permeable barriers, bio-barriers) can be subject to failures due to cracking and biologic penetration, similar to the baseline technologies (grout, slurry walls and cements, landfill caps). In addition, aggressive chemical contaminants could overwhelm any barrier approach. Enhanced post-closure monitoring approaches are also subject to similar failures as the baseline technologies, because they are enhancements to such baseline technologies. Therefore, unanticipated and unsampled heterogeneities of the natural system and cost limitations on technology implementation limit the level to which any technology can be comprehensive. Such failure possibilities require screening of technology and field scale demonstrations to provide information required for site specific implementation by site managers and regulators.

14. Major Technical Challenges:
While innovative and cost-effective solutions are needed for many pressing environmental concerns within the DOE Complex, each facility in detail presents different types of waste treatment problems and transport modes and heterogeneities. One problem presented by this diversity of environmental problems is that restricted technology development often occurs to meet individual site-related problems rather than addressing the scope of the problems at several different sites. It is for this reason that near-surface test beds were proposed under the LANL Barriers and Post-Closure Monitoring Project. These test beds are expected to include both experimental emplacements and actual Solid Waste Management Units at Los Alamos National Laboratory and other DOE/DOD locations.

15. Technical Effectiveness:

15.1. Performance

15.1.1. Remaining Contamination: (contamination mobility reduction, volume reduction, toxicity reduction)
Summary (20 words or less): Permeable-reactive and biodegradation barriers contain and immobilize contaminants within the barrier system, thus reducing the volume.
Further Description (unlimited length): Post-closure monitoring systems provide quantitative information on the extent and stability of the approach.

15.1.2. Process Waste

15.1.2.1. Status of waste (mobility, volume, hazard, recyclability)
Summary (20 words or less): Contaminants will be retained or degraded in barrier materials. For non-degradable contaminants, the barrier system concentrates materials.
Further Description (unlimited length): For residual control the barrier may provide permanent containment, while for higher level or more toxic contaminants the barrier system provides a focused, decreased volume region for treatment with possible recycling of barrier materials.

15.1.2.2. Treatment (needed, available)
Summary (20 words or less): None
Further Description (unlimited length):

15.1.2.3. Decontamination / Decommissioning
Summary (20 words or less): None
Further Description (unlimited length):

15.1.2.4. Disposal (needed, available)

Summary (20 words or less): None
Further Description (unlimited length):

15.1.3. Practicality

15.1.3.1. Foreclose Future Options
Summary (20 words or less): No effects on future options can be seen at this point.
Further Description (unlimited length):

15.1.3.2. Reliability
Summary (20 words or less): The barriers will probably be able to operate unattended with minimal maintenance for long periods of time.
Further Description (unlimited length): The durability of the barrier much depends upon site specific characteristics, such as contaminant type. However, the barriers are reliable for twenty to forty years.

15.1.3.3. Failure Control
Summary (20 words or less): Possibility of waste transport. This technology is intended only as an interim or supplementary measure and requires additional containment
Further Description (unlimited length):

15.1.3.4. Ease of Use
Summary (20 words or less): These systems are designed for independent or automated and continuous operation.
Further Description (unlimited length): Barrier systems require minimal maintenance and can be emplaced using standard construction techniques. Post-closure monitoring systems are being developed and tested for automated and continuous operation.

15.1.3.5. Infrastructure
Summary (20 words or less): No significant infrastructure is required for barrier system maintenance, while post-closure monitoring will require automation systems and sampling points.
Further Description (unlimited length):

15.1.3.6. Versatility
Summary (20 words or less): Post-closure monitoring approaches are integrated with barrier and site design, but are expected to be very versatile.
Further Description (unlimited length): The range of barrier materials selected for near term evaluation focuses on arid soils; however, this approach and the range of potential barrier components is extremely versatile, subject to evaluation at field scale and demonstration for specific sites.

15.1.3.7. System Compatibility
Summary (20 words or less): This may not work with cryogenics, but in general is compatible.
Further Description (unlimited length):

15.1.3.8. Off-the-Shelf (procurement ease)
Summary (20 words or less): This technology lends itself to full commercialization. The components of the system are commercially sourced.
Further Description (unlimited length): The technologies are commercially available and widely used in industrial products. For example, polymers, gels and foams are used for profile control in commercial petroleum recovery operations, and the identical materials are used to stabilize a variety of end-use consumer products.

15.1.3.9. Maintainability
Summary (20 words or less): Periodic maintenance required. Post-closure monitoring systems are automated, while barrier systems will require periodic inspection and evaluation.
Further Description (unlimited length):

15.1.3.10. Safety Measures
Summary (20 words or less): Lightening protection installed.
Further Description (unlimited length):

15.1.4. "Works" (functions as intended):
Summary (20 words or less): As this demonstration is still in the initial phases, data acquisition is not at a point such that analysis is complete.
Further Description (unlimited length):

15.2. Cost

15.2.1. Start-Up Cost
Summary (20 words or less): Depends upon the size of the application. A small application could cost 10 K, while a large application might run into the hundreds of thousands.
Further Description (unlimited length): Estimated at $670 K for FY93 for present field scale demonstration/evaluation.

15.2.2. Operations and Maintenance Cost
Summary (20 words or less): Not available
Further Description (unlimited length):

15.2.3. Life-cycle cost
Summary (20 words or less): Unknown
Further Description (unlimited length):

15.3. Time

15.3.1. Years Until Available
Summary (20 words or less): Components available at present, approximately 1 to 2 years for evaluated systems (follow-on studies of similar length for more diverse materials and applications).
Further Description (unlimited length):

15.3.2. Speed/Rate
Summary (20 words or less): Not available
Further Description (unlimited length):

15.3.3. Years to Finish
Summary (20 words or less): It takes days to emplace. Implementation of barrier and post-closure monitoring systems can take months to years, depending mainly on regulatory processes.
Further Description (unlimited length):

16. Environmental Safety and Health

16.1. Worker Safety

16.1.1. Exposure to Hazardous Materials/Hazards
Summary (20 words or less): Potential health and safety issues are site dependent. Hazards at existing field-scale test facility are electrical systems, lightening strikes, and chemical operations.
Further Description (unlimited length): Other hazards include construction operations during implementation of test cells or field applications.

16.1.2. Physical Requirements
Summary (20 words or less): Standard construction requirements

Further Description (unlimited length):

16.1.3. Number of People Required
Summary (20 words or less): Depends upon the size of placement. Four people for test beds. At a large site, perhaps twenty people.
Further Description (unlimited length):

16.2. Public Health and Safety

16.2.1. Accidents
Summary (20 words or less): None
Further Description (unlimited length):

16.2.2. Routine Releases
Summary (20 words or less): None
Further Description (unlimited length):

16.2.3. Transportation
Summary (20 words or less): Not applicable
Further Description (unlimited length):

16.3. Environmental Impacts

16.3.1. Ecological Impacts
Summary (20 words or less): Minor disturbance of ecosystem.
Further Description (unlimited length):

16.3.2. Aesthetics
Summary (20 words or less): Noise during construction
Further Description (unlimited length):

16.3.3. Natural Resources
Summary (20 words or less): None anticipated.
Further Description (unlimited length):

16.3.4. Energy Demands
Summary (20 words or less): Barriers are passive/chemically reactive, while monitoring systems are designed to require minimal electrical power and can operate on battery systems.
Further Description (unlimited length):

17. Socio-Political Interests

17.1. Public Perception

17.1.1. Proponent Reputation
Summary (20 words or less): LANL is teamed with the University of Houston, considered the world's expert on barriers. Dupont and Pfizer are the leading manufacturers of barrier materials.
Further Description (unlimited length): In post-closure monitoring, LANL has an excellent reputation. ESG especially is nationally known for its expertise in TDR (Time Domain Reflectometry), and Campbell Scientific is one of only two manufacturers of TDR in the US.

17.1.2. Familiarity / Understandability
Summary (20 words or less): Interested parties and individuals are unlikely to familiar with this technology. However, the technology can be described for a wide audience to understand.

Further Description (unlimited length): There may be concerns with barrier integrity, balanced by interests in containment of systems.

17.2. Tribal Rights / Future Land Use

17.2.1. Capacity for Unrestricted Use (terrestrial, aquatic)
Summary (20 words or less): This is primarily intended as an interim measure or supplementary measure.
Further Description (unlimited length):

17.3. Socio-Economic Interests

17.3.1. Economic Impacts
Summary (20 words or less): Unknown
Further Description (unlimited length):

17.3.2. Labor Force Demands
Summary (20 words or less): Unknown
Further Description (unlimited length):

18. Regulatory Objectives

18.1. Compatibility with Cleanup Milestones
Summary (20 words or less): Technology should aid in complying with site closure and post-closure monitoring regulations.
Further Description (unlimited length):

18.2. Regulatory Infrastructure / Track Record
Summary (20 words or less): A major challenge is regulatory limitations and/or constraints on evaluation of radionuclide and mixed waste applications in a field scale demonstration.
Further Description (unlimited length):

18.3. Regulatory Compliance
Summary (20 words or less): Site closure and post-closure monitoring are regulatory requirements under RCRA, CERCLA, SARA, and DOE Order 5820.2A.
Further Description (unlimited length): For hazardous chemical sites the required post-closure monitoring period is 30 years. For radioactive sites that have been closed, DOE Order 5820.2A requires monitoring and maintenance of the site for 100 years.

19. Industrial Partnerships

19.1. Company Names:
Pfizer Chemical, Dupont Chemical, RKK Ltd., University of Houston, University of New Mexico, and Sandia National Laboratories

19.2. Rationale:
This program involves direct partnering with Dupont Chemical, Pfizer Chemical, the University of Houston and the University of New Mexico. In addition, evaluation of technology from RKK Ltd. is ongoing. Discussions are also ongoing with New Mexico Institute of Technology concerning promising technologies, and with EG&G Rock Flats Plant, Chem-Nuclear Geotech (Grand Junction) and Westinghouse Hanford concerning specific or demonstration application sites. The project has recently been integrated into the Mixed Waste Landfill Integrated Demonstration (Sandia National Laboratory).

19.3. Contract Mechanism:
Collaborations with University of Houston and University of New Mexico are present under contract with this program. Interactions with Dupont and Pfizer have included exchange of materials and collaboration on characterization and application evaluation. Formal cooperative agreements are presently under discussion.

19.4. Other Potential Companies:
Zeotech Co., Campbell Scientific, 3M Corp., & Sequoya Minerals. Commercial materials and equipment from Zeotech Co. and Campbell Scientific, respectively, are being used in the present field-scale demonstrations. Preliminary discussions of materials and applications have been ongoing with 3M Corp. and Sequoya Minerals.

19.5. International:
Not applicable

20. Intellectual Property

20.1. Patent Ownership:
To be determined.

20.2. Other Owners:

20.3. Patent Number:

21. Cost Sharing:
Not applicable at this time.

22. Background on this technology (Where did the idea come from? Who else is doing similar work? What have the results been to date? What is the most significant competitor to this technology?):
Chemical and petroleum companies are actively applying barrier technology in enhanced oil recovery operations. Our interactions with University of Houston in characterization and reservoir management approaches for improved oil recovery led to discussions of possible technology transfer opportunities to similar problems in the environmental area. Simultaneously, co-workers at LANL and UNM had been investigating chemical interactions with peat for permeable-reactive barriers to contaminant leachates from uranium tailings and other workers at LANL had been working on biodegradation of organic contaminants. Combinations of barrier components for complex contaminant mixtures and mixed waste became an obvious opportunity. For individual or limited groups of contaminants, a wide variety of academic, government and industrial groups are investigating, demonstrating or applying barrier materials. No single approach competes with the versatility of this effort.

23. Reference Documents:
Janecky, David. "Permeable-Reactive Barrier Systems: Demonstration and Evaluation Summary." In Situ Waste Stabilization and Remediation Workshop. 13-14 April 1993.

Kovarik, F.S., et. al. Barriers and Post Closure Monitoring: 1992 Final Report. Houston: Institute for Improved Oil Recovery, April 1993.

Information reviewed for accuracy (Principal Investigator's initials): KWB