MULTI-AGENCY PERSPECTIVE ON HAZARDOUS SUBSTANCE RESEARCH NEEDS

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ABSTRACT

A forum discussion recently held at the annual Conference on Hazardous Waste Research at St. Louis, Mo., focused on the future of hazardous substance research, technology development, and implementation. Three groups impacted by hazardous waste research were represented at the forum. Representatives from regulatory and other federal agencies, industry, and the academe discussed research priorities, technology transfer needs, and the role of the Hazardous Substance Research Centers in these areas. Hazardous substance research over the past several years has undoubtedly enhanced our knowledge on environmental restoration of the subsurface. However, much important research work remains to be completed. Remediation at some contaminated sites continues to be delayed in search of cost-effective and innovative technologies. Future research needs to be focused on advancing measurement and characterization technologies as well as innovative remediation processes, all of which reduce the cost of environmental restoration. Better coordination among all the stakeholders in order to effectively transfer research results to field scale is an important need of the day.

Key words: *research needs, hazardous waste research, federal agency, industry, academe*

INTRODUCTION

Hazardous substance research and technology development efforts over the past ten years have dramatically increased our understanding while decreasing the cost of environmental remediation. Many government, university, and private organizations have played important roles in this progress. However, the environmental management of certain contaminants and contaminated sites continues to pose significant challenges under new regulatory and multi-stakeholder problem-solving approaches. A forum discussion recently held at the annual Conference on Hazardous Waste Research at St. Louis, Mo., focused on the future of hazardous substance research, technology development, and implementation. Three groups impacted by hazardous waste research were represented at the forum. Representatives from regulatory and other federal agencies, industry, and the academe discussed research priorities, technology transfer needs, and the role of the Hazardous Substance Research Centers in these areas.

In the recent past, several reviews at EPA and the Hazardous Substance Research Centers have attempted to estimate the value of research and have identified approximately $10 in savings for each $1 invested in research. To save another $100 billion in cleanup costs, therefore, there is a need to spend about $10 billion on research and technology development translating to approximately $300 million of research support per year for 33 years. Some application areas related to these research needs are listed in Table 1. The information presented here was collected from a variety of sources (Schwarzenbach et al., 1999; Davis, 1999; Lesney, 1999) and the estimated costs of remediation shown are for current technologies and restoration standards.

FEDERAL AGENCY PERSPECTIVE

Representatives from several federal agencies presented information on future directions of hazardous waste research and technology transfer issues that researchers need to address. Agencies represented at the forum included the U. S. Environmental Protection Agency (EPA), the National Institute of Environmental Health Sciences (NIEHS), the Department of Energy (DOE), and the U.S. Army Corps of Engineers belonging to the Department of Defense (DoD). Key points discussed by the representatives of these agencies are summarized below.

U.S. Environmental Protection Agency

Waste research remains an EPA priority because of the health and environmental risks posed by wastes and the high costs involved in their remediation. EPA's Office of Research and Development has outlined future research strategies and priorities in their publication, Waste Research Strategy (EPA, 1999). The document identifies four research areas focusing on major waste-related environmental problems that include contaminated groundwater, contaminated soils and the vadose zone, emissions from waste-combustion facilities, and active waste management facilities.

Brownfield sites constitute a new focus of EPA. The extent of hazardous substance problems at most brownfield sites across the nation and abroad remains undetermined. For example, Wellston, Mo., which has a current population of about 3,500, has about 400 abandoned properties with the possibility of environmental contamination. Similarly, in Europe, the canton of Zurich, Switzerland, with an area of 1,729 m^2 and a population of 1.18 million, has more than 11,000 suspected contaminated sites (Schwarzenbach et al., 1999). As research focus begins to be directed at the restoration of brownfields, there arises an important need for the development of rapid and inexpensive measurement and characterization methods for these sites.

National Institute of Environmental Health Sciences

NIEHS has also identified research needs and criteria in the area of hazardous wastes. In preparation for resoliciting proposals under the NIEHS/EPA Superfund Basic Research and Training Program, program staff conducted a series of meetings across the U.S. with remedial program managers, community groups, and state and local health and environmental protection officials. The purpose of these meetings was to identify hazardous waste research and program needs to ensure that activities funded under the new RFP would provide the kinds of technical and scientific data needed to manage hazardous wastes in the year 2005 and beyond. Examples of these research and program needs include site evaluation, risk assessment, improved remedial and restorative technologies, long-term monitoring, and increased community participation in the entire process (NIEHS, 1999).

Multidisciplinary environmental and health-effects research are the primary foci of the Superfund Basic Research Program (SBRP). SBRP advocates a unifying framework model for multidisciplinary research (Figure 1), and supports research in areas that include contaminant fate

and transport, exposure pathways, human risks/effects, ecological risks/effects, remediation science, and remediation technology. The program encourages partnerships between participating investigators and stakeholders including the affected communities. SBRP plays an important role in information transfer from research laboratories to appropriate audiences.

DEPARTMENT OF ENERGY

DOE representatives emphasized the need for deployable environmental solutions that will have a significant national impact. DOE intends to continue its support for the development of innovative and effective technology solutions to contain, control, and remediate contaminant plumes and waste sites to environmentally acceptable levels. Management, over long periods of time, of mixed wastes such as those containing radioactive substances co-disposed with disparate hazardous chemicals remains a primary research challenge to this agency.

DOE's Natural and Accelerated Bioremediation Research (NABIR) initiative supports the development of cost-effective bioremediation technologies to clean up sites contaminated with complex mixtures including radionuclides and heavy metals. NABIR encourages multi-disciplinary research among microbiologists, geochemists, molecular biologists, hydrologists, and environmental engineers. Future research needs of DOE include the following:

- decontamination and decomissioning of nuclear reactors and high-level waste tanks containing mixed wastes;
- characterization of landfills containing mixed waste;
- commercialization of developed technology systems through industry and university participation;
- integration of stakeholder participation in decision making;
- development, demonstration, and implementation of innovative systems addressing containment and long-term isolation of subsurface contaminants;
- enhancement of natural attenuation; and
- *in situ* remediation of DNAPLs, metals, unexploded munitions, and radionuclides that minimizes risks while meeting compliance requirements.

DEPARTMENT OF DEFENSE

DoD is responsible for over 10,000 contaminated sites requiring restoration. Research supported by DoD is directed towards developing cost-effective remediation approaches for contaminated sites, and achieving environmentally sustainable operations on all military installations, particularly those utilized for training and testing. In addition to basic research on the biochemical and physiological mechanisms underlying biodegradative processes in normal, extreme, and engineered environments, research needs of DoD also include analytical microbiology and a better understanding of mechanisms for the remediation of contaminated sites.

DoD's Office of Naval Research (ONR) supports research that focuses on cost reductions and improvement in the reliability and acceptability of dredging, managing, and controlling contaminated sediments. ONR's research needs also include development of rapid and inexpensive screening tools; assessment, control, and management of contaminant pathways; demonstration of bioremediation processes that are cost-effective; and development of field approaches for confined facility reclamation. DoD's Waterways Experimental Station (WES) and the Strategic Environmental Research and Development Program (SERDP) support research focused on achieving a fundamental understanding of environmental processes that is critical to answer the question—how clean is clean?

In the next five years, DoD will invest more than a billion dollars in high-performance computing. Environmental Quality Modeling (EQM) is a part of the DoD High Performance Computing Modernization Program which will provide advanced hardware, computing tools, and training to DoD researchers. EQM involves high-resolution modeling of hydrodynamics and contaminant and multi-constituent fate/transport through the aquatic and terrestrial ecosystem and wetland subsystems, and their interconnections with numerous biological species.

Representatives from the U.S. Army Corps of Engineers present at the forum focussed on two important research frontiers in the area of hazardous substance remediation: the necessity of a fundamental understanding of biogeochemical processes controlling bioavailability of xenobiotics in complex environments; and its importance in assessing the achievement of acceptable remediation endpoints. The requirements for predictive technology and tools to evaluate remediation processes were discussed. The importance of defining environmental exposure in relation to target species, space, time, and concentration was also pointed out.

Other significant research and technology needs identified by representatives from the four federal agencies at the forum are summarized below:

- *Establishment of relationships between exposure and risks associated with hazardous materials*. There is a need to quantify exposures and for a technology that is predictive, not reactive.
- *Low-technology solutions and a broadening of multidisciplinary efforts to include cultural anthropology, communications, and economics*. There is an emphasis on low-tech solutions, such as phytoremediation and bioremediation. Transferring research from the bench to the field remains a challenge.
- *Encouragement of multidisciplinary and multifocus research proposals with a required tie-up with industry.* Important research areas are light and dense nonaqueous-phase liquids, methods of supplementing natural attenuation, and radionuclide remediation. Brownfields are seen as an important area to work with important research subjects as diverse as remediation of lead in soil, house molds, and steel industry wastes.

- *Continued interest in research on subsurface contaminants in the vadose zone, biobarriers, decontamination and decomissioning of landfills, underground storage tanks, plutonium disposition, and mixed wastes.* Regulators expressed the need of a solid foundation for decision making. Research using systems and interdisciplinary approaches is essential to build that foundation.

In addition to research and technology needs, representatives from the focus group also placed emphasis on issues related to technology transfer. EPA representatives emphasized the application and transfer of research generated from the centers' activities into solutions that address real-world problems. Research needs to be visibly connected to helping communities manage real problems. Researchers were encouraged to approach regulators to learn what problems need to be solved. Communication between researchers and regulators was deemed essential in bringing solutions to the table. The need to present information on research and technology needs in terms understandable to the public, industry, and non-scientists was highlighted. New developments in information technology have the potential to impact research. The efficacy of the information media needs to be assessed.

INDUSTRY PERSPECTIVE

Representatives from industry present at the forum stressed the need for long-term monitoring to address concerns regarding the use and performance of new technologies in the post-regulatory phase. Problems arising from the transfer of new knowledge from the "flask" to the "field" remain a concern. Setbacks resulting from the non-availability of basic tools to make the processes work effectively in terms of cost and technology continue to limit the progress of research from the bench scale to site implementation. Although it is difficult to assign a dollar value to groundwater, industry prefers to support research focusing on cost-benefit analyses of technologies, particularly those involving mass removals. Industry is interested in lower cost remedies that are semi-passive or passive technologies. Greater university/industry partnership in "fieldback" research, where needs identified in the field are investigated in the laboratory, is desired. The perception that universities are providers of non-biased information will continue to make university-affiliated researchers a valuable resource in environmental restoration.

ACADEMIC PERSPECTIVE

Representatives from the university research community made the following general observations:

- Basic research is very important, as it has the potential to lead to great discoveries with applied results.
- The level of technical understanding at the industrial plant worker/miner level is low and steps to improve technical knowledge at this level should be implemented to advance pollution prevention and safety.
- Researchers need to focus on the purity of systems and understand trace materials and their behavior. Researchers also need to gain a better understanding of contaminant and subsurface characterization. Exploration of new and innovative remediation methods must

continue.

CONCLUSIONS

Hazardous substance research over the past several years has undoubtedly enhanced our knowledge on environmental restoration of the subsurface. However, much important research work remains to be completed. Remediation at some contaminated sites continues to be delayed in search of cost-effective and innovative technologies. Future research needs to be focused on advancing measurement and characterization technologies as well as innovative remediation processes, all of which reduce the cost of environmental restoration. Better coordination among all the stakeholders in order to effectively transfer research results to field scale is an important need of the day.

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Table 1. Estimated remediation costs for selected major applications of hazardous substance research.

Mine tailings and mine waste	$100 to $500 billion
Landfills and waste repositories	$50 to $100 billion
Contaminated soil and water at industrial and spill sites	$80 to $120 billion
Contaminated sediments	$50 to $150 billion
Unexploded ordnance in soil	$50 to $130 billion
Radioactive and mixed waste	$100 to $180 billion
Mercury waste	$150 to $200 billion
Brownfields restoration	$20 to $80 billion

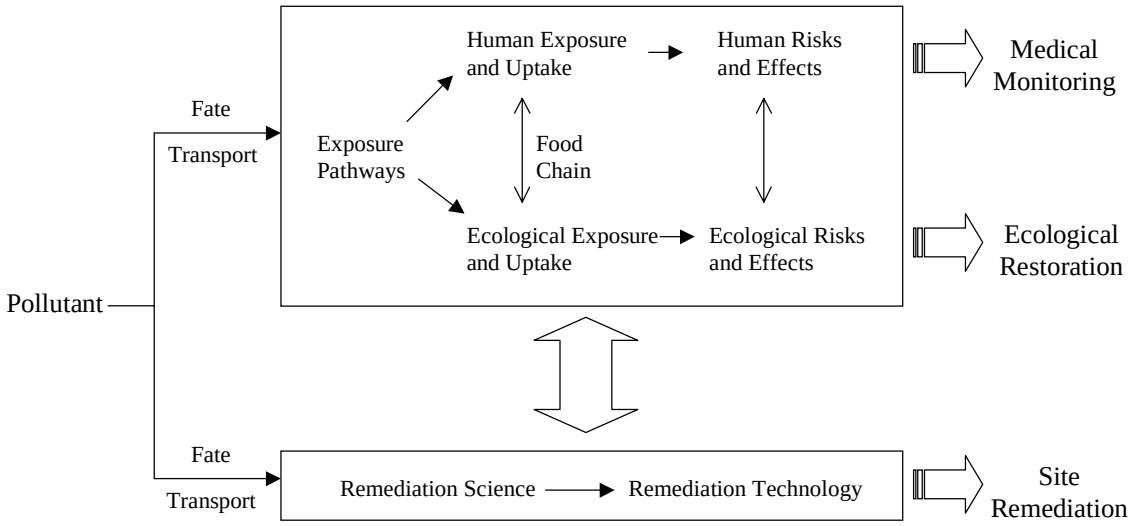

Figure 1. The unifying framework model for multidisciplinary research proposed by the NIEHS-EPA Superfund Basic Research Program (adapted from Suk et al., 1999).