TESTIMONY NOVEMBER 9, 1993 KENNETH OLDEN, PH.D DIRECTOR NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES HOUSE SCIENCE, TECHNOLOGY, ENVIRONMENT AND AVIATION SUPERFUND R & D HEARING

Federal Document Clearing House Congressional Testimony

November 9, 1993, Tuesday

Section: CAPITOL HILL HEARING TESTIMONY

Length: 3990 words

Body

STATEMENT

Of

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Before the

Subcommittee on Technology, Environment, and Aviation

Committee on Science, Space, and Technology

United States House of Representatives

November 9, 1993

Good morning. I am Dr. Kenneth Olden, Director of the National Institute of Environmental Health Sciences, one of seventeen institutes of the National Institutes of Health. We are pleased to present testimony on the ***NIEHS*** Superfund Basic Research Program, a program that has proved to be very successful in expanding our understanding of the problems associated with uncontrolled hazardous waste and in providing some promising new technologies to assist in cleaning it up.

Background

The effect of uncontrolled hazardous waste on human health is one of the most significant public health concerns of the decade. Large numbers of people may be exposed to chemicals known to have or suspected of having effects on reproduction and development, the immune and nervous systems, or which may cause cancer. The need for research in dealing with toxic waste is clear. There are critical gaps in our knowledge about its effects on human health and on how to mitigate these effects through better containment or destruction.

The Congress recognized that the science base is inadequate and in the Superfund Amendments and Reauthorization Act of 1986 (SARA) established a university-based multidisciplinary basic research program at ***NIEHS*** to be funded by the Superfund Trust. In responding to the legislation, ***NIEHS*** initiated a research program calling for the integration of the biomedical, engineering, ecological, and geosciences in a multiproject, multidisciplinary effort to bring together a broad spectrum of scientists to approach the problems of the health effects of toxic waste in a coordinated and comprehensive way. It is this kind of innovative approach that shows great promise for providing answers to the questions most often heard from people whose environment has been affected by uncontrolled hazardous substances: "What are the risks to me and my family and what can science and technology do to help us?"

The ***NIEHS*** Superfund Basic Research Program should be thought of as a prevention program directed towards understanding and reducing the adverse effects on human health resulting from exposure to hazardous substances; therefore, ***NIEHS*** has as one of its mandates under SARA to develop biological, chemical, and physical methods to reduce the amount and toxicity of hazardous substances in the environment. It is important to recognize that the clean up of contaminated soil and groundwater is not only for improvement of the environment, but is also a means by which human exposure and human health risks can be reduced. To this end the ***NIEHS*** Superfund Research Program has been supporting basic and applied research in environmental technologies, ecology, and the geosciences integrated within a framework of health-related research and development.

The ***NIEHS*** currently funds 18 multidisciplinary grants involving over 1000 scientists at 29 institutions working on 142 research projects that are providing an increased understanding of the health and environmental effects associated with Superfund sites and new technologies to monitor exposures and to reduce adverse human health effects through improved containment and destruction of waste site toxic chemicals. No other agency supports this kind of multidisciplinary program.

All research is rigorously reviewed for technical merit by the NIH peer review process. Funding considerations are based primarily on technical merit, programmatic responsiveness, interdisciplinary focus, programmatic balance, ability to fill research gaps, and uniqueness of the research.

Examples of Current Research

Some examples of our research programs in environmental technologies, fate and transport, health effects, and ecology follow:

Environmental Technologies

Waste Site Remediation: Engineers at the University of California-Berkeley have developed a steam injection technology to remove solvents and liquid fuels from soils contaminated by leaking underground storage tanks or spills on the surface. In this method, steam injection wells are located around the perimeter of a contaminant plume. Steam is injected into these perimeter wells and a vacuum extraction well located at the center of the plume removes the contaminant/steam mixture. Laboratory and small scale tests of the technology were promising enough to convince the Department of Energy Office of Environmental Restoration and Waste Management to invest $12,200,000 in a demonstration facility to clean up a twenty year old gasoline spill at Lawrence Livermore National Laboratory. After earlier cleanup efforts, approximately 6700 gallons were estimated to remain in the subsurface. The new technology proved to be so successful that over 7000 gallons of gasoline have been recovered and sent to a recycler for resale. Gasoline recovery rates were 60 times greater than those obtained by older methods like ambient temperature soil vapor extraction and groundwater pumping. This new technology is being considered for the cleanup of a carbon tetrachloride spill in fractured basalt at the Idaho National Engineering Laboratory, is to be applied to a jet fuel spill at the Lemore, California, Naval Air Station, and is a key technology being considered for rapidly closing the Alameda, California, Naval Air Station.

The importance of this ***NIEHS*** program is that there is now a proven technology that can be used to remove volatile solvents, some of them carcinogenic (e.g., benzene), from the subsurface before they reach groundwater resources. Not only are storage tanks at gas stations sources of contaminants in groundwater resources, but pipelines that transport gasoline from southwestern states nationwide are major sources of hydrocarbon contaminants in the subsurface. Many of these pipelines are over 50 years old and are constructed from steel which corrodes and leaks.

Biodegradation of Azo-dyes: Scientists and Engineers at the University of Cincinnati have isolated and engineered novel strains of bacteria that aerobically degrade a number of azodyes which have been linked with bladder cancer in humans. The goal is to reduce the bioavailability and toxicity of these particularly troublesome wastes, thereby providing a more cost-effective approach to controlling them at the source. As a result of the success of this program with organic compounds such as the azo compounds, the researchers are developing a collaborative research effort with the U.S. Ecological and Toxicological Association of Dyes and Organic Pigments Manufacturers to assess the bioavailability and toxicity of metal- complexed dye wastes. This research will provide more accurate data from which to make better management decisions relating to the control of all types of dye waste discharges.

Biodegradation of organic chemicals: Investigators at Utah State University have developed a biodegradation technology for organic chemicals based on the discovery that the white rot fungi that degrade lignin in wood can also degrade a wide variety of otherwise very recalcitrant, toxic environmental pollutants, such as DDT, 2,4,5-T, TNT, pentachlorophenol, creosote, coal tar, dioxin, PCBS, and heavy fuel oils. Following exposure to the fungi, many of these chemicals both singly and in mixtures are completely converted to carbon dioxide and water. The process works in soil. Preliminary evidence shows that it should work in water, thus making it a technology that can be applied to both ground and surface water resources.

Biodegradation of Volatile Organic Compounds (VOCs): Research at Michigan State University/University of Michigan focuses on soil, groundwater and surface water contamination from industrial waste sites. It includes studies on the ability of microorganisms to degrade pollutants in soil and water and uses genetic engineering techniques to assess, understand and improve the degradative capacity of selected microorganisms.

Transformation of Metals by Bacteria: Scientists at New York University isolated bacteria that can transform chromium from Cr(+6) to Cr(+3), thus reducing the toxicity of this element. At Cornell University, scientists have modified bacteria to enhance their ability to accumulate mercury and cadmium. Because metals such as mercury, cadmium and chromium are common toxic waste site metals, their removal by bacteria in biofilm reactors from waste site leachates represents an effective method of reducing possible human exposure via drinking water or consumption of contaminated fish.

Supercritical Extraction/Wet Oxidation: Engineers at Syracuse University are assessing the technical feasibility of supercritical extraction/wet oxidation processes to remove and destroy halogenated aromatic hydrocarbons from contaminated soils removed from waste landfill sites. The advantages of the supercritical process over conventional waste treatment methods include enhanced solubility of organic chemicals in water, their complete oxidation, simplicity of separation of pollutants from the waste stream, and reduced energy costs. Because of the lower temperatures at which it operates the reactor does not promote the formation of NOx or other toxic byproducts. With funding from both ***NIEHS*** and the Niagara Mohawk Power Corporation, the researchers plan to develop this technology from a laboratory device to a bench-scale apparatus with a goal of demonstrating the effectiveness of this technology at existing PCB- contaminated waste sites owned by Niagara Mohawk.

Incineration: Eliminating toxic chemical by-products produced during the incineration of waste chemicals is an especially difficult problem because of the inability to detect them while they are being formed. An investigator at the University of California-Berkeley has developed a new photofragmentation/laser-induced fluorescent technique to measure chlorinated hydrocarbons at atmospheric pressure at both ambient and combustion temperatures. This technique has the potential to act as a real-time monitor for observing formation of toxic chemicals during combustion. It may allow for much better and more cost-effective monitoring of destruction efficiencies and by-product emissions from incinerators. If fully successful, this will be the first real-time monitor to detect and identify design and operating conditions that promote the formation of toxic by-product chemicals during the incineration of hazardous wastes. This technological advance may also have applications in reducing exhaust emissions from automobiles and fossil fuel electrical power plants. The ability to detect the formation of toxic by-products, such as polycyclic hydrocarbons, during the combustion process may make it possible to relate formation processes for these pollutants directly to chamber design and operating conditions. With this information, design and operating conditions of automobile engines and combustion chambers can be modified to minimize formation of air pollutants and reduce exhaust emissions without reduced efficiency in energy conversion.

Fate and Transport

Sequestration of Waste by Clay Minerals: Investigators at Michigan State University have developed modified clay minerals that enhance the sorptive capacities of clay minerals for organic groundwater contaminants. The enhanced ability to contain contaminant plumes and slow their movement in the subsurface is an important component in in situ bioremediation of waste sites. Retarding and inhibiting transport of groundwater contaminants may allow sufficient time for microorganisms to degrade and mineralize organic chemicals found in toxic waste sites.

Transport of VOCs and NAPLS: A scientist at Michigan State University is using laboratory column experiments to identify the factors that control the transport of volatile organic compounds (VOCS) and nonaqueous phase liquids (NAPLS) in the unsaturated zone of the subsurface where most waste site and liquid fuel storage tanks have been located. She is developing mathematical models that simulate and predict the transport of these compounds in a wide variety of soils. The importance of this work is that it may help to explain how interactions between contaminant chemicals and the porous structures of the subsurface affect rates of contaminant movement in groundwater. Before effective long-term waste site remediation methods can be developed and implemented, interactions and processes occurring in the subsurface that control the rates of transport of contaminant VOCs and entrapped NAPLs must be determined and quantified.

Transport of Chlorinated-Benzene Compounds: Researchers at the University of Arizona have found that low levels of trichloroethylene (TCE) facilitate the movement of chlorinated-benzene compounds in soil that is primarily inorganic. The opposite is true in soil that is mostly organic, where in the presence of TCE, chlorinated-benzene is more likely to be absorbed by the soil, thus retarding progress toward groundwater. This new information is being used to improve models for organic contaminant transport.

Health Effects

Biomarkers for Exposure and Effect: In determining human health risks, data on exposure to waste site chemicals are essential. Teams of researchers at UC-Davis, UC-Berkeley, MIT, Rutgers, New York University, and the University of Washington have developed a number of enzyme-linked immunosorbent assays (ELISAS) to detect and quantify exposure to waste site chemicals in humans and other species. One example is the development of an immunoassay with a detection limit of 10 parts per trillion for the herbicide atrazine. (The triazine herbicides, such as atrazine, are good indicators of agricultural chemical contamination of groundwater resources.) The assay has been used to detect the presence of atrazine in fog water, demonstrating a new route by which contaminants can move from a point source to expose a wide area, and also to monitor an herbicide spill. Another example is the development of a quick and sensitive method for detecting DNA protein crosslinks as a biomarker of exposure to toxic substances, such as formaldehyde and chromate. Using previous methods, it took three days to perform 20 analyses; using this new technique, several hundred can be finished in a few hours with similar levels of sensitivity.

Scientist at the University of Washington have developed a technique that measures the accumulation of a specific biomarker (porphyrins) in human urine directly attributable to mercury exposure. Model studies have shown that dentists with measurable but low levels of mercury in the blood also had 3-4 fold elevations in porphyrin metabolites in urine. This technique is now being applied to Native American populations residing near a hazardous waste site that contains mercury.

ELISAs are especially useful, because they are rapid, reliable, and inexpensive. They can be used to detect exposure to toxic chemicals in readily available biological tissues, e.g. blood and urine, and can be used to detect the presence of toxic chemicals in environmental samples, e.g., contaminated ground and surface water. They make it possible to rapidly determine the presence of toxic pollutants in the field. Such a field detection capability is an important component of monitoring networks needed to determine the location of pollutants and of waste site remediation. In addition, because of their simple design, ELISAs can be used successfully by people who are not experienced technicians. (Home pregnancy test kits are a commercial example of this technology.)

Toxic Equivalency Factors: A research team at Texas A&M University has developed toxic equivalency factors that rank the toxicity of halogenated aromatic compounds, such as dioxin and PCB. This approach has been adopted worldwide by numerous regulatory agencies, including the U.S. EPA, to assess more accurately and cost effectively the risks associated with hazardous waste sites.

Mutational Spectrometry: Researchers at the Massachusetts Institute of Technology are determining if chemicals from hazardous waste sites are contributing to genetic changes in populations around the sites. Their approach, called mutational spectrometry, is based on the premise that each chemical mutagen produces a unique pattern of genetic changes in the DNA. A new technological has been developed that speeds the previously arduous process of measuring patterns of mutations in human cells and tissues.

Cardiac Teratogen: Studies at the University of Arizona have shown that trichloroacetic acid in drinking water appears to be a cardiac teratogen when delivered in the first trimester of pregnancy. This is of considerable importance as trichloroacetic acid occurs not only from the breakdown of trichloroethylene, but also from chlorination of water supplies.

Polychlorinated Biphenyls (PCBs): SUNY-Albany researchers have used fish to show PCB leaching from the Mohawk Indian Superfund site in New York. This finding led to reduction in consumption of fish from contaminated water by Mohawk women, especially those who are pregnant or nursing. This change in diet is a significant public health advance since PCBs are directly fetotoxic as well as being secreted in mother's milk to affect adversely the nursing newborn.

Wood Preservatives: Wood treatment operations in the past have contributed to soil and groundwater contamination with pentachlorophenol (Penta). Researchers at the University of North Carolina are examining the ability of an enzyme produced by a microbe to catalyze the degradation of Penta. The characteristics of the products formed depend on the pH at which the reaction occurs. At a neutral pH the degradation products are about as toxic as Penta itself; however, under acidic conditions degradation results in a nontoxic product. These results suggest that this is a naturally occurring process which may be exploited to remediate contaminated soil and groundwater at wood treatment facilities.

Ecology

Sentinel Species: A scientist at Colorado State University is using mosquitos to look for heavy metals' presence in waste sites. Another at the University of Nevada is evaluating the use of cabbage looper moth to monitor mercury pollution near Superfund sites. A Cornell University researcher is evaluating health effects in dogs as markers for PCB exposures. Responses in household pets are often good indicators of waste site problems or chemical migrations and presence in neighborhoods.

Bioavailability of Pollutants: Researchers at Clemson University have found that nestling starlings who inhabit nest boxes placed on a Superfund site had changes in biomarkers indicating exposure to polyaromatic hydrocarbons and PCBS. These preliminary studies show that wildlife may be used to assess whether pollutants present in the soil are actually bioavailable and can enter the food web.

Field and Laboratoly Assays: A team of researchers at University of California-Berkeley have developed and validated three techniques that will be useful in both field and laboratory evaluations of effects of toxic substances. The first compares fertilization rates and developmental success in sea urchin embryos.The second technique is a nematode mutagenesis assay that can be used to study effects in soil, sediment, and fresh and salt water. The third technique uses red blood cells of tadpoles to characterize their fitness.

Coordination With Other Agencies

NIEHS works closely with our colleagues at the Agency for Toxic Substances and Disease Registry (ATSDR). Our staffs communicate both formally and informally on issues related to Superfund R&D. We have jointly sponsored several conferences. In addition, I have organized an ongoing series of annual meetings for the heads of all agencies or divisions of agencies that are involved in environmental R&D. On November 23, I am meeting with the EPA Assistant Administrator Designate for the Office of Solid Waste and Emergency Response (OSWER), the office with program management responsibility for the ***NIEHS*** Superfund programs. I look forward to that meeting as the beginning of a new era of cooperation between OSWER and ***NIEHS***.

Environmental Technology Transfer

It is vital to the success of this program, as well as to the advancement of the science of hazardous waste management, to disseminate and utilize the knowledge gained from this research. To accomplish this task, ***NIEHS*** has implemented a technology transfer strategy. The major objective of this strategy is the dissemination of nonproprietary programmatic and research information for use by other interested parties. This includes developing and maintaining various databases, developing and distributing program-related documents and media productions, as well as sponsoring and conducting conferences and workshops. These approaches are presently being implemented. The second objective of this strategy is the utilization of information and inventions developed within the program. This includes providing financial assistance to grantees to support their moving from basic to applied or scale-up research and information to connect grantees with potential research collaborators in other government agencies, universities, and industries.

To increase opportunities for communication among researchers and those interested in progress of current research, ***NIEHS*** has sponsored 15 conferences, workshops, and meetings since 1990. Topics have included such areas of research as the application of molecular biomarkers in epidemiology, assessment of human exposure to hazardous chemicals, health effects of combustion by-products, bioaccumulation of organic chemicals, and dehalogenation and its environmental implications. In 1993, ***NIEHS*** has supported and organized the following conferences: Second International Meeting on the Molecular Mechanisms of Metal Toxicity and Carcinogenicity (January); Biodegradation and Its Role in Reducing Toxicity and Exposure to Environmental Contaminants (April); Fate, Transport and Interactions of Metals: A Joint U.S.-Mexico Conference (April); First International Congress on Human Health Effects of Hazardous Wastes (May); Third International Congress on Toxic Combustion By-Products (June); Pediatric Environmental Health Research Workshop (June); Conference on Genetic and Molecular Ecotoxicology (October); and the 1993 Pacific Basin Conference on Hazardous Waste Research (November).

Additional Resources

In response to your question how additional resources would be useful, research in the following areas would fill critical voids: biomarkers, mixtures, fate and transport, biodegradation, combustion, effects on ecosystems, environmental equity, and effects on children's health.

Conclusion

The information on health effects and the environmental technologies developed by the ***NIEHS*** Superfund Research Program offer great promise and demonstrated progress for reducing public concern about hazardous waste sites, including those for which the federal government is responsible. The improvement in the science base that underlies risk assessment is crucial to policymakers who must make risk management decisions. The economic value in terms of job creation, competitive technologies for export, and cleanup money saved for federal, state, and local governments and the private sector is obvious.

NIEHS would be pleased to answer any questions regarding our Superfund Basic Research Program.

Classification

Language: ENGLISH

Subject: MEDICAL SCIENCE (92%); MEDICINE & HEALTH (91%); SUPERFUND (91%); TOXIC & HAZARDOUS SUBSTANCES (91%); ENVIRONMENT & NATURAL RESOURCES (90%); GOVERNMENT & PUBLIC ADMINISTRATION (90%); GOVERNMENT RESEARCH FUNDING (90%); HAZARDOUS WASTE (90%); HEALTH DEPARTMENTS (90%); LEGISLATION (90%); LEGISLATIVE BODIES (90%); RESEARCH & DEVELOPMENT (90%); RESEARCH INSTITUTES (90%); TESTIMONY (90%); US CONGRESS (90%); US ENVIRONMENTAL LAW (90%); ECOLOGY & ENVIRONMENTAL SCIENCE (89%); GEOLOGY & GEOPHYSICS (89%); SCIENCE & TECHNOLOGY (89%); US FEDERAL GOVERNMENT (79%); BIOENGINEERING (78%); BIOMEDICINE (78%); EMERGING TECHNOLOGY (78%); ENGINEERING (78%); ENVIRONMENTAL CLEANUP (78%); ENVIRONMENTAL INDUSTRY (78%); ENVIRONMENTAL LAW (78%); ENVIRONMENTAL RESEARCH (78%); HUMAN EXPOSURE ASSESSMENT (76%); SOIL CONTAMINATION (76%); PUBLIC HEALTH (75%); BIOMEDICAL ENGINEERING (73%); ENVIRONMENTAL TECHNOLOGY (73%); WATER POLLUTION (73%); CANCER (71%)

Company: NATIONAL INSTITUTE FOR COMMUNITY BANKING INC (92%); NATIONAL INSTITUTE OF BUSINESS MANAGEMENT INC (92%); NATIONAL INSTITUTE FOR COMMUNITY BANKING INC (92%); NATIONAL INSTITUTE OF BUSINESS MANAGEMENT INC (92%); NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES (97%); NATIONAL INSTITUTES OF HEALTH (91%); NATIONAL INSTITUTES OF HEALTH (91%); US HOUSE OF REPRESENTATIVES (84%); US HOUSE OF REPRESENTATIVES (84%)

Organization: NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES (97%); NATIONAL INSTITUTES OF HEALTH (91%); NATIONAL INSTITUTES OF HEALTH (91%); US HOUSE OF REPRESENTATIVES (84%); US HOUSE OF REPRESENTATIVES (84%)

Industry: SUPERFUND (91%); TOXIC & HAZARDOUS SUBSTANCES (91%); HAZARDOUS WASTE (90%); HEALTH DEPARTMENTS (90%); BIOMEDICINE (78%); ENGINEERING (78%); ENVIRONMENTAL CLEANUP (78%); ENVIRONMENTAL INDUSTRY (78%); SOIL CONTAMINATION (76%)

Geographic: UNITED STATES (79%)