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A REVIEW OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY'S RESEARCH PROGRAM ON THE PREVENTION AND CONTROL OF HAZARDOUS MATERIAL SPILLS

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Summary

This paper is a status report on a number of the projects in progress at the Industrial Waste Treatment Research Laboratory of the U S Environmental Protection Agency at Edison, New Jersey The actual causes of numerous hazardous material spills have been documented and analyzed to assign priority to operational areas in which spill prevention and control procedures are urgently needed Spill alert systems are ready for installation on marginally safe earthen holding pond dikes Fail-safe systems are being evaluated to reduce spillage from overfilling and from transfer line rupture The handling of spills in municipalities has been addressed with particular attention to the maintenance and utilization of secondary sewage treatment facilities during spill events

Among the physical and chemical treatment systems that have been or are being produced are trailer-mounted units for processing contaminated water Also, special devices are being designed for the dispersion and recovery — where necessary — of adsorbents and counteractive chemical reagents for *in situ* treatment of polluted water bodies Plastic foams have been developed to dike or confine spills and to plug leaks in ruptured containers A pickup truck-mounted collection unit, consisting of a battery-powered pump and a self-deploying plastic storage bag, has been constructed and tested

Nearing final testing is a "Sea Curtain ', which extends from the bottom of a stream to the air above The "Curtain" can be used to isolate a water column that is being contaminated by a soluble, sinking, or floating hazardous material discharged from shore or in stream Gelling and solidification agents have been shown to be effective in immobilizing spilled hazardous materials Systems are being built to reprocess treatment agents for reuse and to detoxify whatever agents or recovered materials cannot be salvaged Field-use packets and other easy-to-deploy items are being developed to trace spills in water and to assess the effectiveness of cleanup Procedures for enhanced, in-place, biological degradation of spilled hazardous materials are under test

The thrust of the Laboratory's program in these and in related projects is toward the demonstration of practical procedures, hardware, and suitably engineered systems for the prevention and control of spills of hazardous materials

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Introduction

The world's industries are producing, consuming, handling, transporting, and storing ever-increasing quantities and varieties of hazardous materials These materials will be required in larger quantities and will become more broadly distributed as the industrialization of the underdeveloped nations proceeds and the world's standard of living rises There is a dichotomy in that these very materials that are so beneficial in improving man's lot can also be harmful to his health and welfare when misused, discarded, chronically discharged into the ecosystem, or spilled on water or land. Hazardous substances are recognized as presenting a real and growing threat of accidental — and, unfortunately, even of intentional — spillage into water bodies ranging from small, freshwater brooks and ponds to estuaries, seas, and oceans The hazardous and toxic materials of concern in spills include not only pure substances and mixtures but also wastes and residues from manufacturing, processing, and end use

In the United States, Section 311 of "The Federal Water Pollution Control Act Amendments of 1972" (Public Law 92-500) specifically directs attention to the development of regulations and approaches for controlling and preventing hazardous material discharges into the aquatic environment. Responsibility for the U.S Environmental Protection Agency's national research program in this area rests with the Industrial Waste Treatment Research Laboratory (IWTRL) of the National Environmental Research Center, Cincinnati. The Hazardous Spill Technology Branch of IWTRL at Edison, New Jersey, is actively engaged in research projects to develop, demonstrate, and make available to private contractors and local, state, and Federal officials the technology for the prevention, control, removal, and cleanup of spilled hazardous pollutants. The program is essentially hardware-oriented, and most of the work is carried out on an extramural basis, *i e.*, through contracts and grants.

Enactment of Public Law 92-500 corrected the inability of "The Water Quality Improvement Act of 1970" (Public Law 91-224) to discourage spill discharges of substances other than oil into the navigable waters of the United States Section 311 of P L. 92-500 will — as soon as hazardous materials are officially designated — require reporting of spills, provide for the assessment of penalties against the discharger, force the application of response mechanisms to clean up the spill and mitigate spill damage, and encourage development of preventive and contingency procedures for minimizing the possibility of spills Until the requirements of Section 311 are fully implemented, however, there will continue to be thousands of unreported hazardous material spills annually, and ameliorative and cleanup steps will not be rigorously pursued

Spill data

A project (Factory Mutual Research Corp , Norwood, Mass , under EPA

Contract 68-03-0317) has been undertaken to identify the causes of hazardous material spills during process, transfer, transit, and storage operations Properly weighted and statistically adjusted lists of spill causes, developed under this project, are being used by the EPA to establish priorities for future research on the prevention and control of hazardous material spills. Data on 15,000 incidents, which potentially involved spillage of hazardous substances during the period January 1972 through June 1974, were carefully reviewed. Most reports could not be verified in sufficient detail to provide sound historical data on the spills and to allow a reliable statistical analysis of the events. Approximately 1300 incidents were, however, suitable for spill analysis

The distribution of the 1300 documented spill incidents by operational area was found to be as follows. in-transit, 57%, loading/unloading, 25%, in-plant processing, 10%, and in-plant storage, 8%. These data are undoubtedly biased since most in-plant spills — especially smaller ones — are simply unreported, and the best reporting of transit spills is for those involving rail and truck tankers The highest proportion of the documented spills (43%) were caused by rupture, puncture, or other failure of non-tank containers. Ruptures and punctures of bulk tanks resulted in the next highest proportion (25%). Tank overflow and other leakages (17%) rank next, followed by hose or transfer system failures (8%) Other or unknown causes accounted for approximately 7% of the reported incidents. A system based on quantity spilled and toxicity was devised to rank spill incidents by "hazard potential".

The frequency of spills as a function of "hazard potential" was, as can be expected, found to follow a decreasing exponential law, with the number of low "hazard potential" spills much greater than the number of catastrophic incidents. The documented spill events were classified into four operational areas, namely, in-plant storage, in-plant processing, in-transit, and loading/unloading It was determined that in-plant storage spills were more likely to be of high "hazard potential" than spills in the other operational areas. The area in which an incident is next most likely to be of a high "hazard potential" is in-plant processing followed by the in-transit and loading/unloading areas. The probability of having no spill during transfer, processing, etc., is, of course, high; but, in terms of environmental protection, the safety record is not particularly commendable, as one can judge by considering the vast number of spill-contaminated water bodies [1] Similar examination of reported events, with respect to primary causes, showed that incidents involving rupture or puncture of bulk tanks are most likely to have high "hazard potentials", followed in ranking by incidents involving tank overflow or other leakage Hose and transfer system failure incidents rank next, while rupture or puncture of non-tank containers (cartons, bags, etc) is the least likely to be within the high "hazard potential" categories One can, therefore, expect severe spills to occur during in-plant and storage operations from overfilling and transfer line breaks and, also, during transit from overturn, puncture, derailment, etc

It must be realistically noted, however, that the potentiality for the occurrence of a spill can never be totally eliminated, spills of hazardous materials will continue to take place A practical goal can only be to substantially and significantly reduce the probability of a spill's occurrence and to ameliorate the environmental impact of those spills that do occur. From its inception, the Hazardous Spill Technology Branch has devoted great effort to: prevention of spills by the development of spill warning/alert systems, retardation and halting of the flow of the material into a watercourse or into the subsurface water table, control of the spill, removal of the spilled material from the receiving water body or from land, and, finally, detoxification and cleanup The technology developed thus far under these efforts has been transferred to the general public in the form of official EPA publications and via two National Conferences on the Prevention and Control of Hazardous Material Spills The first conference was held in Houston in 1972 [2] and the second in San Francisco in 1974 [3]. As an index of increasing awareness of the importance of spill prevention and control, it should be noted that almost triple the number of papers were presented at the second conference, which was attended by almost twice the number of people.

Some of the work of the Hazardous Spill Technology Branch will be briefly discussed in the following paragraphs according to the several areas in which the effort has been programmed, namely prevention, control/removal, containment, and identification/tracing.

Prevention

Fail-safe devices

Comments have already been made on the documentation and analysis of historical data to rank the causes of spills and the severity of the resulting spill situations, as well as to indicate areas where new work is required.

As a direct output of this detailed study of spill causes, two research projects are now underway. The objective of one of the projects (Science Applications, Inc , McLean, Va., under EPA Contract 68-03-2039) is to design and demonstrate, under actual operating conditions, a low cost transfer line system that will automatically shut down transfer operations when there is evidence of a severe leak or line rupture. The other project (Factory Mutual Research Corporation, Norwood, Mass., under EPA Contract 68-03-2054) is geared toward the development and testing, under actual use, of simple, reliable, foolproof liquid-level-sensing gauges specifically designed to prevent processing and storage tank spills that result from overfilling. Obviously, these two tasks lie in the area of spill prevention, which is the best cure for the spill disease.

Spill alert device

A project (Drexel University, Philadelphia, Pa., under EPA Grant R-802511) on the development of an acoustic emission-based spill-alert device for assessing the stability of lagoon embankments has received wide press coverage and has elicited about 200 inquiries for further information Large quantities of hazardous wastes are confined by earth embankments Although the design and construction of earth dams is well within the state-of-the-art, there are innumerable improperly designed or constructed dikes, these fail regularly — often with especially disastrous consequences, such as occurred when an embankment containing mine waste tailings at Buffalo Creek, West Virginia, abruptly failed and caused 92 deaths and approximately 1100 injuries, as well as untold environmental and property damage [4] Dike failure is preceded by stress release, which is accompanied by detectable acoustical emissions Both interparticle movement (sand) and cohesive bond breaking (clay) generate sounds, which can be picked up by rods inserted into the earth (Figs 1, 2, and 3). By coupling a transducer (an "accelerometer") to the rod, the sound energy is converted to an electrical signal, which is characteristic of soil stress release and can be distinguished from other noise sources in the earth. Dike stability can be assessed as the lagoon is being filled or emptied. However, marginally stable earth dikes generate almost constant acoustic emissions, even when the level of confined fluid is not changing The acoustic emission system is a non-destructive testing device that will be valuable in identifying prone-to-failure dikes, it can be used to rate the continuing integrity of dams that are being actively stressed (*e g* , by run-off from heavy rains) so that remedial measures can be promptly undertaken. The system is simple in design and rugged in nature. The emission-transmitting rods can be installed once and left in place for periodic checking with the portable sensing system, which functions somewhat like a sophisticated stethoscope The U S Department of Agriculture arranged for testing of the acoustic emission device at two dams in Pennsylvania and one in Nebraska; Bethlehem Steel is adapting the device for evaluating landfill loading by storage piles of iron ore at Sparrows Point, Maryland, Philadelphia (Pennsylvania) International Airport is using the device to assess the soil stability of a landfill operation undertaken in connection with an aircraft runway extension program.

Spill contingency plan

A model contingency plan is being developed (Allegheny County Sanitary Authority, Pittsburgh, Pa , under EPA Grant S-801123) for handling spills of hazardous materials in a municipal waste collection and treatment system serving a large metropolitan area. A survey of stored hazardous materials and of sewered industrial wastes is being analyzed. Preventive measures, to protect a secondary treatment plant from major spills that enter the interceptor system, are being assessed in a 30,000 gal/day pilot plant that closely models the 150 million gal/day treatment plant

Control/removal

Treatment with mass transfer media in flowing streams

Both free-floating and "tea bag"-contained mass transfer media (activated carbon) systems are being evaluated concurrently (Battelle-Northwest Laboratories, Richland, Wash , under EPA Contracts 68-03-0330 and 68-03-2006) to

Fig 1 Lagoon embankment showing three acoustical waveguide rods (3/8-in o d reinforcing rods) from embankment (left) to monitoring station (center) View is of downstream side of embankment

Fig 2 Personnel taking acoustical emission reading to determine lagoon embankment stability showing waveguide rods (left), transducer (accelerometer — covered with plastic film) and support frame (center), and instrument package (right)

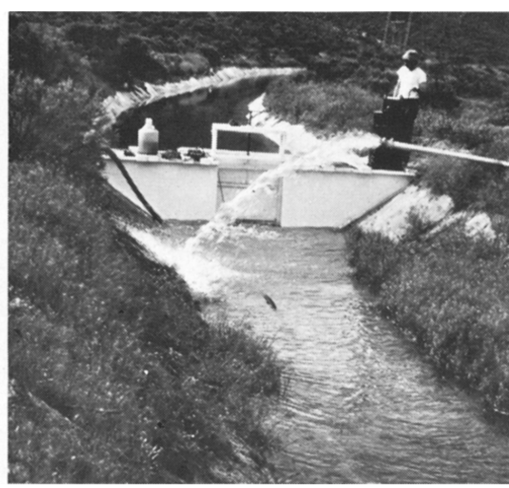

Fig 3 Closeup of acoustical emission measurement equipment showing electrical transducer (accelerometer) attached to waveguide rod (left), portable amplifier (in leather case, right), and electric pulse counter (in leather case, left)

Fig 4 Captive stream showing plastic-lined reservoir (top), partly opened sluice gate (upper center), operator controlling addition of dye marker/hazardous material (right, upper center), augmentation water pipe for improving dye dispersion (right to center), and flowing stream (center to lower right) View is upstream determine the quantities of material required and the efficiency of pickup and removal of spilled soluble hazardous materials in a flowing, captive stream (Fig 4). In the "tea bag" system, a thin layer of granular activated carbon is confined between large pieces of loosely woven synthetic fabric. The carbon "sandwich" is stitched so that the carbon is confined in small (1 5 in. x 1 5 in) patches. The sheet of "tea bags" so formed is attached to a flotation collar so that the assembly extends through the water column and is carried by the current, though at a slower rate than the flow speed Effectively, the contaminated water passes through the "tea bags" and the contaminant is adsorbed by the carbon In the flotable carbon system, ballasted activated carbon is deposited on the bottom of the watercourse and slowly rises to the surface, adsorbing dissolved hazardous materials from the water during its passage Under turbulent conditions, the carbon is more uniformly distributed throughout the water column. The "tea bags" are retrieved manually and the floatable carbon is collected (under quiet water conditions) by techniques normally used in oil spill control, *e g* , booming and skimming

Mobile physical/chemical treatment system

The 200-gal/min physical/chemical treatment trailer (Rexnord Corporation, Milwaukee, Wis , under EPA Contract 68-01-0099), which was successfully used in a demonstration on clean-up procedures for removing creosote that had been spilled in the Little Menomonee River in Milwaukee, was recently used to process almost one-half million gallons of water in a small pond that had been contaminated by a spilled herbicide (dinitrobutylphenol) A spill of 200 gallons of polychlorinated biphenyls (PCB) into an estuary was also processed through the treatment trailer The heavier-than-water PCB was vacuumed from the stream bottom and the PCB/mud was separated from the saline water by flocculation and sedimentation. The concentration of dissolved PCB in the clarified water was then reduced (by carbon adsorption) to about 60 parts per trillion The 45-ft. flat-bed treatment trailer (Fig. 5) contains three 7-ft.-o d x 8.5-ft -high glass-lined tanks (each filled with 6000 lb of granular activated carbon) and three 3 5-ft.-o d. x 6.5-ft -high tanks filled with a mixed media filtering agent (anthracite and sand). The carbon tanks and the mixed media filters are piped so that they can be operated in various series/parallel combinations The electric power for the pumps and controls is provided by an on-board diesel electric generator. All control equipment is mounted on a console A 15,000-gal collapsible sedimentation and chemical reaction tank and several 2000-gal pillow storage bladders are also stowed on the trailer

Mobile "Dynactor"/separator treatment system

A 250-gal/min trailer-mounted dynamic reactor ("Dynactor") complete with high rate clarifiers is presently under construction (Industrial Bio-Test Laboratories, Inc , Northbrook, Ill., and RP Industries, Inc , Hudson, Mass., under EPA Contract 68-03-0228) This sytem will be used to treat a wide

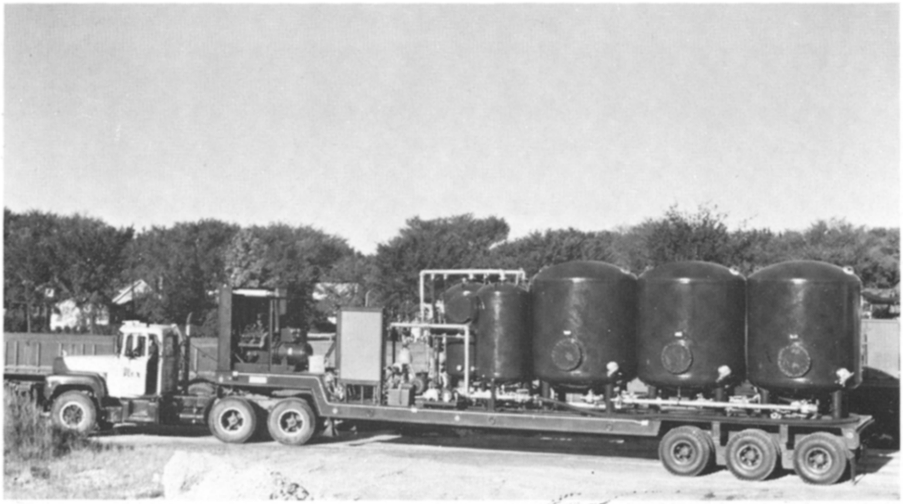

Fig 5 Physical/chemical treatment trailer showing three activated carbon columns (right), two (of three) mixed-media filters (one not visible),(center), control panel and diesel-electric generator (left) Nominal throughput is 200 gal/min (series configuration) but can be increased to 600 gal/min (parallel configuration)

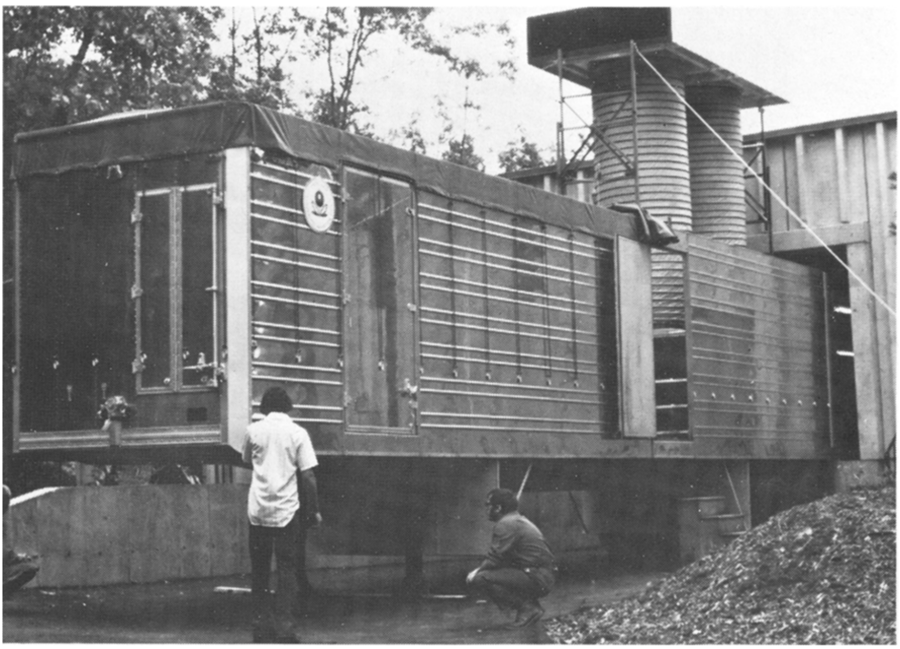

Fig 6 Dynamic reactor ("Dynactor")/separator semitrailer showing collapsible reactor column extended for use (upper right-of-center) Diesel-electric generator, control panel and bank of high-rate separators are mounted inside the trailer Nominal processing rate is 250 gal/min

variety of hazardous material spills in watercourses where confinement of the spill to a small area is possible In this system, contaminated water is "atomized" into a mist at the top of a 4-ft.-i.d. x 10-ft.-high collapsible cylinder ("Dynactor") and admixed with concurrently introduced finely powdered activated carbon (and/or other reagents such as neutralizers and precipitants). Because of the small sizes of the water droplets and reagent particles (great surface-to-volume ratio), reaction is very fast (0.1 sec) and contaminants are effectively removed. The carbon/water mixture is partially separated in a high rate separator/clarifier When iron oxide has been added along with the carbon, the underflow (sludge) from the clarifier can be further dewatered by passing the water/carbon/iron oxide sludge into a special magnetic separator, in which the sludge is held magnetically onto a moving belt and the squeezed-out water flows from the device countercurrently. (The sludge is scraped from the belt with a doctor blade.) Tests with a 10-gal/min model demonstrated that settled creosote/mud, vacuumed from a river bottom, could be effectively separated from water (15% slurry), such that very high quality water could be returned to the river and the concentrated sludge could be landfilled. The total 250-gal/min system, which is now about 70% complete, is mounted on a 45-ft. totally enclosed semitrailer (Fig. 6) that is equipped with a diesel electric generator for powering the pumps, etc The "Dynactor", including a 2-ft.-high plenum chamber, collapses to standard trailer height for transport and is erected in place for field use

Mobile carbon regeneration system

A project (MSA Research Corporation, Evans City, Pa., under EPA Contract 68-03-2110) is now underway to design, construct, and demonstrate, in actual use, a semitrailer-mounted system for the on-site regeneration of activated carbon that has been used in hazardous material spills cleanup. The system will be self-contained, except for fuel and water supplies, and will include a 230 V a.c diesel electric generator. The design throughput will approach 3000 lb./day. Provision will be made for introducing the carbon to a direct-fired rotary kiln; quenching the high temperature (1800 °F) regenerated carbon, and detoxifying all off-gases so that there is no air quality deterioration.

Dredging and processing system

A system for removing and processing settled hazardous materials from impoundment bottoms was demonstrated (Hittman Associates, Inc., Columbia, Md , under EPA Contract 68-03-0304). Simulated hazardous materials were removed from 28-ft.-long x 8-ft.-wide test areas in a 1.7-acre x 6-ft.-deep pond by a commercial 1500-gal/min, trailer-transportable, pontoon-mounted vacuum dredge (Fig 7) The system (Fig. 8) for removing the suspended solids and simulated hazardous materials from the dredged slurry provided for processing in three stages initial solids removal by means of two elevated, high-rate-settling bins, secondary separation with a bank of six hydrocyclones, and final filtration. Two filtering devices were used either separately or in series for the

Fig 7 Pontoon-mounted vacuum dredge in use to remove contaminated silt from pond bottom showing (from left to right) towing winch, control arms for submerged auger, cabin, effluent hose, and diesel engine Effluent line is supported by air-filled bags and is arranged in a snake-like configuration on pond Nominal pumping rate is 1500 gal/min of 20% slurry.

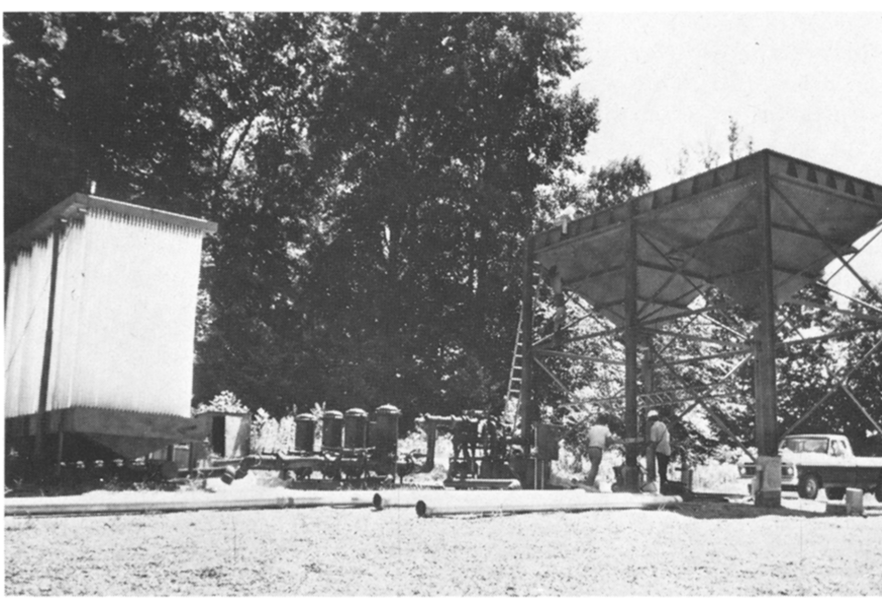

Fig 8 Processing system for vacuum dredge effluent during assembly showing elevated settling bins (right), hydrocyclones (right-of-center), cartridge filter bank (left-of-center), and fabric tube filter assembly (left)

final filtration step (1) a commercially available, cartridge-type filter and (2) a specially designed bag-type fabric filter. Each device had automatic backwash. A microscreen strainer is now under active consideration as a more rugged replacement for the fabric filter The built-up filter cake serves as the actual filtering element in these units

In situ biological treatment

Several promising bacterial cultures have been identified for *in situ* degradation of spilled hazardous materials (University of Texas, Austin, Tex., under EPA Grant R-802207) The active strains were produced by taking mixed seed cultures from the activated sludge of an industrial-municipal secondary sewage treatment facility and subjecting the cultures to various concentrations of the hazardous material in question To date, several organisms have been successfully cultured and used to degrade a variety of organic chemicals in both laboratory-scale and pilot-scale (aquarium) experiments. Most notable was the degradation of phenol, nitrophenol, and methanol using mixed cultures in which the dominant bacteria appears to be the *Pseudomonas* type. Studies have also shown that these cultures are free of pathogenic organisms and that no toxic or noxious sludges result from the degradation process. The use of these bacteria in the environment should, therefore, be safe The next phase of this project will involve the development of storage and reculture methods and the evaluation of the safety and efficiency of various techniques for deploying the bacteria at spill sites

Containment

Collection bag system

In the area of land spill containment, a battery-operated pump and furled 7000-gal plastic collection bag system has been demonstrated (MSA Research Corporation, Evans City, Pa., under EPA Contract 68-03-0205). The system (Figs 9 and 10) is designed to collect and temporarily store diked or pooled spills of hazardous fluids until appropriate removal equipment can be brought to the scene. The 4-ft.-high system is mounted on a 4-ft x 5-ft pallet. The unit weighs about 1000 lb. and can be loaded by a fork-lift onto a small pick-up truck for transport Ease of deployment by not more than two men has been achieved. The system can remain on the truck bed during use since the furled (folded) bag is self-deploying. Both a battery-powered electric pump and an explosion-proofed gasoline engine direct-drive pump are available. Nominal pumping rate is 100 gal/min at a 15-ft. suction head. The plastic-coated fabric bag consists of a header and three fingers that have a total capacity of 7000 gal One hundred feet of 2- or 2.5-in chemical hose are stored on a pallet-mounted reel After collection of the spilled hazardous material, the bag can be emptied by using the filling pump to transfer the contents to a truck tanker or other container for removal. An improved version of the collection system is currently scheduled for fabrication The present polyvinyl-

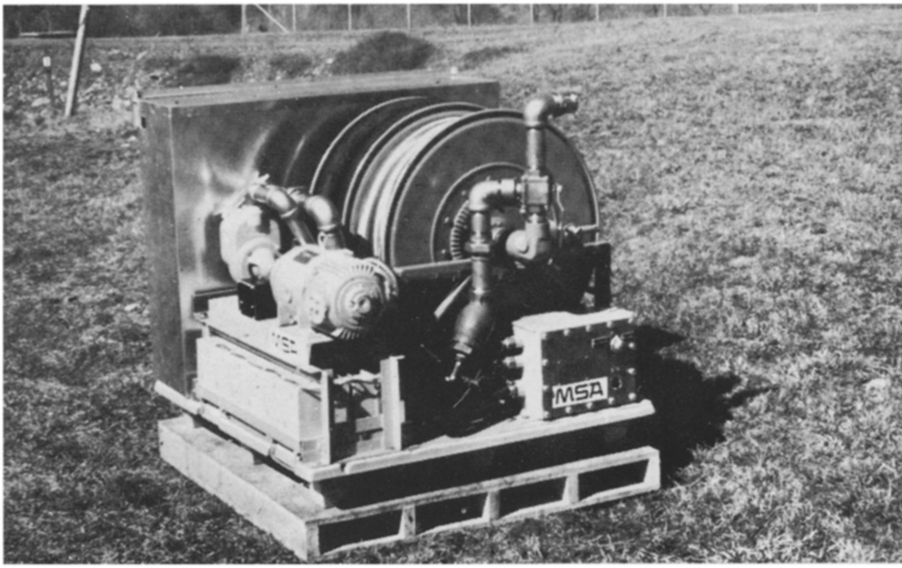

Fig 9 Pallet-mounted pump and collection bag system showing control box (lower front, right-of-center), influent hose reel and plumbing (center), housing for stowing 7000-gal bag (center, behind reel), and electric motor and pump mounted above rechargeable battery pack (front, left-of-center) System is normally carried on and operated from the bed of a small pickup truck Nominal pumping rate is 100 gal/min

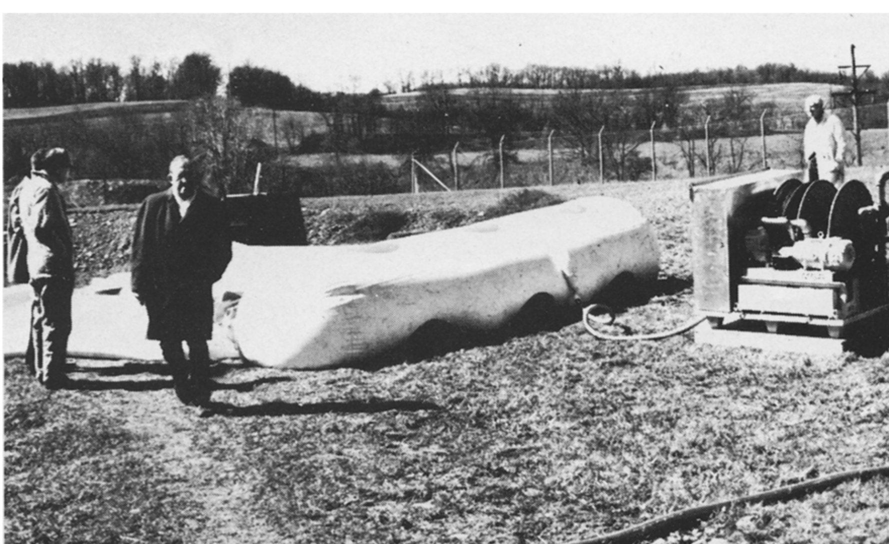

Fig 10 Pump and collection bag system (deployed) showing pallet-mounted pump, battery, and reel assembly (right), filled manifold header (center), and three partially filled "finger" bags (one of three visible) (left) Palletized unit will remain on truck, the bag is self-deploying

chloride-coated polyester fabric bag will be replaced by a polyurethane-coated fabric to improve handling capabilities. An improved method for transferring the fluid from the plastic bag to another container is under development. In a scheduled field demonstration, the second generation collection bag system will be tested in connection with a portable foam barrier system, which will be used to dike a spilling hazardous material

Foam diking system

This diking system (see above) is presently being modified to improve the foam's adhesion to wet surfaces The present system is a 60-lb. back-pack device that generates approximately 100 ft^3 of two-component, very rapid set-up polyurethane foam. The foam adheres well to most dry surfaces (pavement, earth, etc.) for making stable dikes and can also be used to plug storm drains on streets to prevent spilled hazardous materials from entering sewer systems The diking system has been designed as a compact, portable device to be carried by individual operators such as truck drivers or railroad train personnel.

Physical barrier system

Plans are presently being made to test and evaluate, in a flowing stream, the modified version (second generation) of the hazardous spill containment barrier system (Ocean Systems, Inc., Reston, Va , under EPA Contracts 68-01-0103 and 68-03-2168). After the first model of the barrier system was constructed and field tested, the barrier was redesigned to improve its mechanical integrity and functional characteristics The modified barrier was engineered not only for increased strength but also for improved chemical and abrasion resistance Unlike the conventional oil booms, which only confine floatable insoluble materials, the barrier system (sometimes referred to as the "Sea Curtain") was designed to contain, in watercourses, spilled soluble hazardous materials that dissolve throughout the water column Insoluble substances with density greater than one (which sink to the bottom) can also be contained by this barrier system. The system is an impenetrable reinforced plastic curtain that completely surrounds the spill source and spans the water column from the bottom of the watercourse to the water/atmosphere interface. The bottom of the barrier is fixed to the water's bottom with a mooring system employing explosive anchors A water-inflated bag on the bottom portion of the barrier provides a seal between the barrier and the bottom of the watercourse. The top of the barrier is maintained above the water surface by an air-inflated flotation collar that is part of the barrier. A vertical seam in the barrier permits multiple numbers of individual barriers to be joined together to form a longer barrier

Gelling agent system

Work is presently underway (Calspan Corporation, Buffalo, N Y , under EPA Contract 68-03-2093) to develop, test, and demonstrate a portable system for dispensing a multi-purpose gelling agent formulation The system will utilize a powder dispenser to remotely apply the gelling agent to a hazardous liquid which has been spilled on land The gel formulation is being designed to immobilize the spilled material in order to prevent its flow into nearby water bodies and/or its percolation into ground water supplies. Once immobilized, the spilled material can be collected with a front-end loader or hand shovel The gelling agent consists of five separate components, which can be applied mixed together as a "universal gel" or singly to solidify specific classes of hazardous substances such as hydrocarbons, oxygen-containing organics, ionic or highly polar organics, aqueous solutions, etc

Leak plugging system

Additional work (Rocketdyne Division of Rockwell International Corporation, Canoga Park, Calif., under EPA Contract 68-03-0234) on the one-man operable, foamed-in-place plastic plug for stopping the leakage of hazardous materials from damaged or ruptured containers has resulted in major improvements in design The latest concept utilizes an open cell urethane foam sponge A tube extending into the sponge along its axis has openings through which rapidly expanding (and setting) two-component polyurethane foam can be introduced into the interior of the sponge A neoprene sleeve on the outside of the sponge prevents or restricts passage of the leaking chemical into the sponge The sponge is forced through the rupture (Fig 11) into the container, and polyurethane foam is delivered through the tube into the sponge. The sponge swells both inside and outside the hole (typically swelling to many times the original volume of the sponge) (Fig. 12). The tube is held in place while the foam expands and hardens (15—20 sec) The final result is a hard plug, firmly locked in place, that stops the leakage of liquid from the container A prototype leak plugging system (similar to that shown in Fig 11, but utilizing a back-pack foam supply unit) has been successfully demonstrated in leak-sealing tests both on land and under water

Identification/tracing

Portable field detection kit

EPA has entered into an "Interagency Agreement" with the U S Army (Edgewood Arsenal, Aberdeen Proving Ground, Md.) to develop a portable field kit for use by spill response personnel in detecting and tracing the plumes of a wide variety of spilled hazardous materials Both field-use probes and off-the-shelf test packets are being incorporated in a unified, self-contained kit The system is generally useful when the spilled hazardous material either has a characteristic property (color, pH, etc) or has been identified The concentrations of some spilled materials can be determined semiquantitatively An evaluation of the efficiency of the tests and probes will include laboratory and field investigations to determine interferences and minimum detectable levels Two prototype kits will be delivered to EPA along with manuals and reagents necessary for their use

Fig 11 Foamed-in-place leak plugging system showing CO_2 capsule-driven two-component foam generator (lower right), foam-filled plug inserted in "leak" (right-of-center), and operator with control/guide wand (left) System is being assembled as a back-pack unit The equipment (upper right, above tank) controls head and flow rate of "leak" during testing

Heavy metal spill warning device

A device for detecting spills of heavy metal salts and their solutions was evaluated (Calspan Corporation, Buffalo, N.Y., under EPA Contract 68-03-0287) under natural conditions in a suburban stream in Western New York State The unit, a "cyclic colorimeter", is capable of detecting low levels of the pollutant in the presence of natural background color and turbidity This is accomplished by periodically injecting small amounts of an indicator (sodium sulfide) into a "reaction chamber" through which the water being sampled is flowing When pollutants (heavy metal ions) are present, variations in optical transmittance — observed by means of a light source and a photo-detector — occur at the frequency of indicator injection. Results of the evaluation showed that the device is capable of functioning under "real world" conditions, if proper maintenance is performed at 2-week intervals.

Insecticide spill warning device

The "CAM-1" organophosphate or carbamate insecticide alarm system has been given some additional field testing to determine synergistic effects, as well

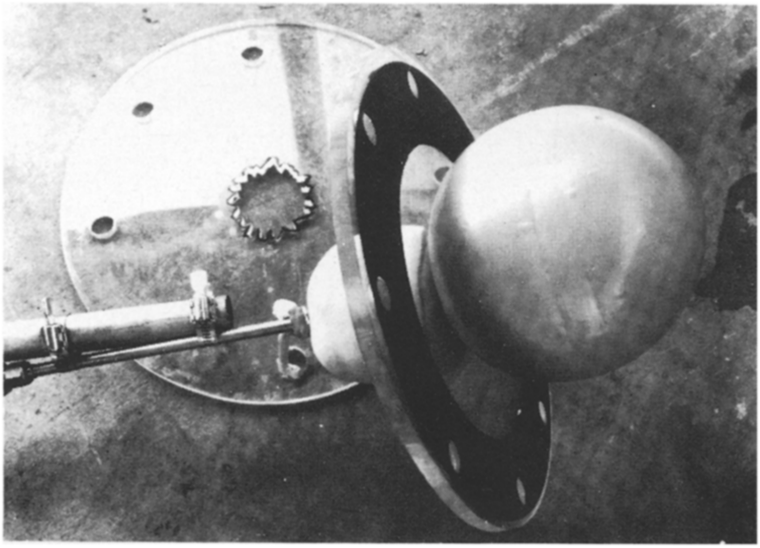

Fig 12 Foamed-in-place leak plug showing sponge (covered with protective elastomer sleeve) expanded inside (right) and outside (left-of-center) of "test leak disc" (center) and control/guide wand (left) A spare "test leak disc" is also shown (upper left-of-center)

as potential interferences (Midwest Research Institute, Kansas City, Missouri, under EPA Contract 68-03-0299). The system checks for the presence of spilled insecticides at toxic levels in water The water is passed through a porous pad coated with an immobilized enzyme (cholinesterase) at a rate of 1 l/min for 2 min Water-borne insecticide reacts with and correspondingly inactivates the enzyme The residual enzyme activity is determined in a subsequent 1-min test cycle in which a substrate is passed through the enzyme-coated pad and the extent of substrate hydrolysis, which is an inverse measure of the concentration of insecticide in the water, is measured electrochemically.

Broad-based spill warning system

An in-stream system capable of continuously detecting the broad variety of hazardous materials spilled into the Nation's waterways is being designed and fabricated (Rocketdyne Division of Rockwell International Corporation, Canoga Park, Calif , under EPA Contract 68-03-2080). The system will consist of a number of individual off-the-shelf probes and sensors, each capable of detecting one or more classes of hazardous materials. Acids and bases will be detected by a pH electrode, aromatic compounds by ultraviolet absorption, ionic compounds by a conductivity probe, organic compounds by a total organic analyzer or suitable substitute, oxidizing and reducing substances by an oxidation—reduction potential electrode, and other miscellaneous compounds by various commercially available or EPA-developed sensors. These components will be integrated into a prototype warning system, and sensitivity and reliability of the system will be determined in the laboratory for selected representative hazardous materials The system will be modified, if necessary, and evaluated for a suitable period of time in a test stream at the contractor's Santa Susanna (California) Field Laboratory Complex.

Final remarks

A point has now been reached where several items of equipment have been developed and field-tested More are "in the wings" and will presently be available for actual use It is beyond the scope of the Hazardous Spill Technology Branch's charter to build replicate units or to actually enter into routine hazardous spill control, amelioration, and cleanup. Every effort is being made, however, to draw attention to the equipment that has been engineered and field-evaluated It is the intent of the Branch to continue to produce hardware that is actually suitable for spill site use. In this brief review, it has not been possible to present more than a cursory description of the equipment or an assessment of the performance.

References

1 I Wilder and J Lafornara, Control of hazardous material spills in the water environment, Water and Sewage Works, 119 (1972) 82—86
2 Control of Hazardous Material Spills, Proceedings of the 1972 National Conference on the Control of Hazardous Material Spills, Houston, Texas, March 21-23, 1972, sponsored by U S Environmental Protection Agency and University of Houston (Texas), Graphics Management Corp , Washington, D C , 1972, pp 1—223 (Also available from American Institute of Chemical Engineers, New York)
3 Control of Hazardous Material Spills, Proceedings of the 1974 National Conference on the Control of Hazardous Material Spills, San Francisco, California, August 25-28, 1974, sponsored by American Institute of Chemical Engineers and U S Environmental Protection Agency, American Institute of Chemical Engineers, New York, 1974, pp 1—377
4 Disaster in the hollow, TIME, The Weekly Newsmagazine, New York, March 13, 1972