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Third Forum on Innovative Hazardous Waste Treatment Technologies: Domestic and International

Dallas, Texas
June 11-13, 1991

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ABSTRACT PROCEEDINGS

THIRD FORUM ON INNOVATIVE HAZARDOUS WASTE TREATMENT TECHNOLOGIES: DOMESTIC AND INTERNATIONAL

Dallas, TX
June 11-13, 1991

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OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE
U.S. ENVIRONMENTAL PROTECTION AGENCY
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Chlorinated benzene and HCH were also removed, although beta and epsilon HCH seemed not to be biologically degradable. Loadings of up to 2.2g/m^3/h were used and still good results were attained. Usage of the RBC resulted in a cost reduction of about 30-40 percent. Both contaminated soil vapor and groundwater were treated with good results. Stripping of volatile compounds was less than 1 percent. Removal efficiencies of up to 99 percent were obtained. Loadings of 22 g/m^3/d were used. The UAC and Biopur are both very simple processes and are easy to build. The costs to build and operate this system are small and therefore the process will be competitive to physical/chemical treatment systems.

ENHANCED COMPOSTING FOR COLD-CLIMATE BIODEGRADATION OF ORGANIC CONTAMINATION IN SOIL

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Bioremediation of soils contaminated with hazardous wastes is becoming a preferred technology because of its simplicity, lack of residuals requiring special handling, and low cost relative to traditional alternatives. Bioremediation was evaluated for a coke works site in northern Norway near the Arctic Circle, characterized in 1989 as having significant contamination by polycyclic aromatic hydrocarbons (PAHs). About 20,000 tons of soil containing PAHs (ca. 500 mg/kg) were excavated. Groundwater at the site contained ca. 2-3 mg/l and 0.4-1.6 mg/l naphthalene and benzol. A pilot study was conducted in 1990, in which 1,000m^3 of soil were treated in an enhanced composting system. Composting was chosen over landfarming or slurry reactors because of: low capital and operating costs; on-site capability (low area requirement); minimal development requirements; and capability for cold-climate, year-round operation.

metal ions (over calcium and magnesium), functions well with solutions with high dissolved solid content, and is capable of reducing metal ions to ppb levels. Once bound to the AlgaSORB®, metal ions can be stripped in a highly concentrated form.

This new technology has been demonstrated to be an effective method for removing toxic metals from groundwater. Metal concentrations can be reduced to very low ppb levels. An important characteristic of the binding material is that high concentrations of common ions such as calcium, magnesium, sodium, potassium chloride and sulfate do not interfere with the heavy metal binding. Waters containing a total dissolved solids content of several thousand and a hardness of several hundred ppm can be successfully treated to remove and recover heavy metals.

The process has been demonstrated to be effective for mercury removal from contaminated groundwater by benchtop and pilot treatability studies through EPA's SITE Emerging Technology Program. In addition the process has been shown to be effective for mercury and uranium removal from contaminated groundwater from DOE sites at Hanford, Oak Ridge, and Savannah River through DOE's Applied Research and Development Program.

CASE STUDIES: SOLIDIFICATION/ STABILIZATION

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This abstract summarizes three case studies of use and performance of Silicate Technology Corporation (STC)solidification/stabilization processes: a demonstration project for a coal gasification/car shredder facility, STC's EPA Superfund Innovative Technology Evaluation (SITE) demonstration project, and a full scale remediation project at a battery recycling plant. STC technologies have been used in the full scale remediation of over 400,000 cubic yards of contaminated soils and sludges in numerous projects throughout the country.

STC performed an extensive pilot scale on-site stabilization study in October 1990. This site contained three major types of contamination from a coal gasification plant that used to exist on the site and an auto shredder salvage

success rate of 98.7%. The remaining 1.3% of the treated materials were crushed and successfully retreated resulting in an effective 100% successful treatment of all contaminated soils. STC professionals assisted the client's engineers in the development of site work plans and in regulatory approvals.

WASTECH: SOLIDIFICATION/STABILIZATION PROCESS

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WASTECH, INC. entered the EPA SITE Program to illustrate the overall effectiveness of its processes in dealing with organic contaminants. By applying the results of a dedicated research and development program, WASTECH demonstrates a high degree of success in treating volatile organics, semivolatile organics, and heavier organic mediums found in sludges, soils, and debris as well as actual raw waste streams. This treatment process proves effective at the bench, pilot, and full scale.

This paper provided a brief summary of WASTECH's participation in the SITE Program. All analytical data presented were obtained by independent testing laboratories for validation.

SITE TECHNOLOGY DEMONSTRATION SUMMARY – SITE PROGRAM DEMONSTRATION OF A TRIAL EXCAVATION AT THE MCCOLL SUPERFUND SITE

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ON SITE SOIL VAPOR EXTRACTION (SVE) OF CONTAMINATED SOIL

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The extent of soil contamination is enormous in the industrialized countries and the overall costs of remediation are extremely high. Excavation of the contaminated soil is a very effective method of removing pollution. Nevertheless, excavation can sometimes be difficult or even impossible. Although there is a lot of experience in the USA and Germany, SVE can be considered as a new remedial technology. However, good insight into the performance of SVE can give more possibilities for the application of the system. In this paper three applications of SVE are presented: first, an in situ SVE of a site contaminated with toluene; second, an air-based in situ bioreclamation of a site contaminated with gasoline; third, an on-site application of SVE at a site contaminated with perchloroethylene.

To select the most suitable remedial technique for a specific site it is necessary to calculate the costs. In order to estimate the duration of the SVE a relatively simple spread sheet model has been developed.

At Site 1, a former paint factory, toluene contamination was caused by the spillage of solvents. Concentrations up to 2000 mg/kg were found. The remedial action techniques considered were excavation, soil flushing, and SVE. For financial and practical reasons SVE was considered the best method. After 6 months of operation the toluene concentration in the soil dropped to ± 1 mg/kg. The withdrawn concentration in the soil vapor dropped from 8 gr/m3 to ±50 mg/m3; the air flow was 150m3/h. A tracer experiment gave a good insight into the geohydrological situation.

At site 2, a petrol station, an SVE extraction system was placed. The contaminated area was situated under a highway and soil was heavily contaminated with gasoline (11-18g/kg). The withdrawn soil vapor and groundwater were treated together in a biological treatment system developed by TAUW Infra Consult B.V (a patent is pending). Within one year approximately 2700 kg of gasoline was removed by means of the SVE system. The biological removal rate was approximately 7 mg C/kg/day. The treatment efficiency of the new

A documentation program has demonstrated the plant's decontamination efficiency for a number of soil types from Denmark, West Germany, and Norway, and for very different contamination sources.

The successful tests have included soil contamination ranging from solvents over oil products to heavy tar fractions. These trials prove that the plant can be used to combat very concentrated pollution and that the process can meet the strictest decontamination requirements.

Concurrently with technical tests, the authorities' approval and comprehensive safety analyses, including the fire and emission risks, have taken place as documentation.

ZERO AIR EMISSIONS GROUNDWATER AND SOIL REMEDIATION USING THE AWD INTEGRATED SYSTEM: A SITE PROJECT IN OPERATION FOR 3-1/2 YEARS

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The Lockheed Aeronautical Systems Company (LASC) was issued a cleanup and abatement order by the Los Angeles Regional Quality Control Board based on data obtained in late 1987. The soil and the groundwater were contaminated with trichloroethylene (TCE) and perchloroethylene (PCE). The order required soil cleanup to start August 1, 1988, and groundwater remediation to begin September 15, 1988.

AWD Technologies was selected on February 1, 1988, to design, install and operate a remediation system. AWD used its fast track project techniques to complete the $4 million project in seven and one-half months, meeting the mandated deadline. More importantly, the system developed by AWD and later patented, provided the following benefits:

Cost:	One-third of conventional technology cost
Environment:	No air emissions
Permitting:	Obtained in three weeks
Image:	Positive television and newspaper coverage

has been demonstrated on both bench-scale and pilot-scale systems. The DWS entails the application of an aqueous solution during a high-pressure spray cycle followed by a turbulent wash cycle. The aqueous cleaning solution is recovered and reconditioned for reuse concurrently with the debris-cleaning process, which minimizes the quantity of process water required to clean the debris.

This paper presented the results obtained during the second field demonstration of the DWS, which was conducted at a pesticide-contaminated site in Chickamauga, Georgia. The data presented indicated the effectiveness of the system for the removal of pesticide and herbicide from the surfaces of metallic debris, as well as the efficiency of the closed-loop solution- reconditioning system that is built into the DWS. In addition, this paper also addressed the conceptual design of a full-scale debris washing system.

DEVELOPMENTS AND OPERATING EXPERIENCE IN SOILCLEANING, A PROGRESS REPORT ON THE DEVELOPMENTS IN CLEANING SOILS WITH CHLORINATED HYDROCARBONS, AND THE DEVELOPMENT OF A WET CLEANING METHOD FOR CONTAMINATED SAND

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NBM Bodemsanering B.V., subsidiary of NBM Amstelland N.V., the second building and construction group in The Netherlands, has developed an indirect heated thermal treatment system and has become one of the leading firms in The Netherlands in the cleaning of soil and the execution of projects for soil pollution.

Soil pollution comprises a broad spectrum of problems. In developing a soil cleaning process it is necessary to define areas of interest. As a first area of interest, NBM elected to clean soil containing pollutants which are hard to break down. In the first phase, NBM concentrated on cyanide, aromatic hydrocarbons, and oily-type pollutants. NBM developed an indirect heated thermal system using a dryer and a rotary tube-furnace. The development of the system was presented at last year's conference.

EXPERIENCE ACQUIRED WITH THE OECOTEC HIGH - PRESSURE SOIL WASHING PLANT 2000 IN CLEANING CONTAMINATED SOIL

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As you are aware, soil exchange has been the most commonly used form of land reclamation up to now.

This soil exchange does not solve the problem but only relocates it. Moreover, this is becoming increasingly difficult, as landfill space is becoming more and more scarce, the fees for depositing at the landfill sites are increasing correspondingly and new administrative regulations for transporting and depositing contaminated substances have been issued. There is, therefore, a demand for an innovative solution to soil exchange and for an improvement from the ecological point of view.

Klöckner Oecotec has been working on the new technology of high-pressure soil washing since 1986. To date, some 250,000 metric tonnes of different soils have been cleaned with three industrial-scale plants. Other plants will be started up in the near future. The high-pressure soil washing process is used for rehabilitating the former sites of steel and gas works, coking plants, chemicals factories and shipyards. The capacity is up to 50 metric t/h. This technology can be used both in the form of a mobile plant on site and as a stationary plant in a waste disposal centre. It is characterized by a high degree of acceptance among the population which has become sensitized to matters of pollution.

The high-pressure soil washing plant consists of sixty 40-foot containers or modules. The single containers can be transported either by truck or train. Complete dismantling and re-construction of the plant including transportation from one site to another takes about two weeks. As the plant is supplied with power from its own diesel generators, it is not reliant on the public supplies.

Thanks to its modular design, the plant may be readily adapted to changing soil conditions and alternating contamination.

Although C-G Process economics are a strong function of the feed properties and capacity requirements, commercial experience to date indicates that a complete C-G Unit can be built and operated for about $50 per dry ton of solids processed.

B.E.S.T. SOLVENT EXTRACTION TREATMENT OF TOXIC SLUDGE, SEDIMENT AND SOIL

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This paper described the current status of the Resources Conservation Company (RCC) B.E.S.T. solvent extraction process. The latest bench and pilot scale treatability test data were presented, demonstrating the excellent removal efficiency of this process for a wide range of contaminants including polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), and pesticides.

Development of the B.E.S.T. process for treating hazardous oily wastes began in 1984 following reauthorization of the Resources Conservation and Recovery Act (RCRA). Laboratory work by RCC demonstrated that the process can separate RCRA-listed petroleum refining oily sludges into three fractions; oil-free water; recyclable oil; and dry, oil-free solids. A second-generation pilot plant was designed, constructed, and operated to demonstrate the feasibility of this process for treating oily sludges.

Based on data from the operation of this second-generation pilot unit, RCC constructed a commercial scale B.E.S.T. unit designed to treat petroleum refining sludges (pumpable sludges). In 1987, this transportable B.E.S.T. unit completed the cleanup of 3700 cubic yards of acidic, oily, PCB-contaminated sludges at the General Refining Superfund site near Savannah, GA.

Recently, RCC constructed a third-generation pilot unit to develop data for a B.E.S.T. process to treat non-pumpable wastes such as soils and sediments. This unit is currently being operated at the U.S. Army Corps of Engineers Waterways Experiment Station. This project is part of the EPA soil and debris BDAT development program.

INNOVATIVE CONCEPT FOR EVALUATION OF IN-SITU TREATMENT OF CONTAMINATED SOIL AND GROUNDWATER

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A peninsula-shaped site in a fishing harbour situated close to the greater Copenhagen area was found to be contaminated with volatile aromatic compounds, water-soluble organic solvents, chlorine-containing organic solvents and hydrocarbons. Since 1914 the site has been used as a storage and handling area. At first it as used for fuel oil products and later for organic solvents. Leaking of materials from the storage area uncovered the pollution and a number of separate investigations were carried out. The storage area has been characterized horizontally and vertically with the following activities: drilling, chemical analyses, ecotoxicological tests, soil characterization, groundwater modelling, groundwater treatment, and full-scale in-situ treatment of soil and groundwater combined with a laboratory study on the degradation potential on soil from the actual site.

Two separate test areas (each of 25 m^2) on the site were erected with strippers down to a depth of 4 m^2 in combination with air extraction units. The test area was characterized with chemical analyses on soil and groundwater before and after a test period of about 2 months. Soil samples were also tested for the content of micro-organisms.

The test results showed that values of the residual concentration in soil and groundwater could be accepted by the Copenhagen County, especially for the soil but also for the groundwater after treatment on site and recirculation to the site.

As a result of the promising full-scale studies, a total full-scale in-situ and on site treatment plant is now in the detailed planning phase. The treatment plant will be erected in the beginning of 1992, when the frost has left the soil and the weather is getting warmer.

IN-SITU GROUNDWATER REMEDIATION OF STRIPPABLE CONTAMINANTS BY VACUUM VAPORIZER WELLS (UVB): OPERATION OF THE WELL AND REPORT ABOUT CLEANED INDUSTRIAL SITES

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This paper presented an in-situ method that can remove strippable substances, e.g., volatile chlorinated hydrocarbons and BTEX, from the subsurface groundwater zone, capillary fringe, and unsaturated zone. The contaminated groundwater is stripped in situ by air in a below-atmospheric pressure field within a vacuum vaporizer Well (unterdruck-verdampfer-brunner, UVB). The contaminated air employed for the stripping process and soil air removal via suction is cleaned using activated carbon.

The UVB method uses a specially designed well with two screen sections, one at the aquifer bottom and one at the groundwater surface. The UVB technique produces a vertical circulation flow in the area surrounding the well, which encompasses the whole aquifer. The general structure of the flow is represented in longitudinal sections by numerical results. In three-dimensional views, the calculated separating stream surfaces of the capture zone, the circulation zone, and the downstream flowing zone are shown. Further, the sphere of influence, the capture zone of a well or well field, and other parameters for dimensioning a well or well field are presented using dimensionless diagrams.

The operation and the effects of the UVB technology were explained in detail as well as the assumptions used for the numerical calculation of the three-dimensional flow surrounding the wells. The numerical results were presented using diverse plots and diagrams.

Two extended examples demonstrated groundwater and soil remediation at sites located in the Rhine-Ruhr area and Berlin using different installations of the UVB system. At both sites, the subsurface had been contaminated by volatile chlorinated hydrocarbons by degreasing processes at metal treatment companies. The respective UVB installations used for the remediation of the sites and the success of the operations were demonstrated. The decrease of con-

air stripping and (b) without air stripping but with devices to add nutrients and/or electron acceptors within the well to activate biodegradation in the circulation system surrounding the well.

The circulation flow surrounding a UVB is generally represented for a vertical longitudinal section in the direction of the natural groundwater flow by streamlines for different cases. Colored photos presented a view of the calculated three-dimensional separating stream surfaces of the different water bodies in the outer flow field of a UVB: the captured, the circulating, and the downstream flowing water. For cleaning a wide plume, the corresponding water bodies for three UVB installations in one line normal to the natural groundwater flow were displayed.

Graphs derived from the numerical calculations can be used for the dimensioning of UVB installations. For sites without natural groundwater flow, the sphere of influence and the differences of the hydraulic heads between the top and bottom of a double-screened well, through which a discharge is pumped, were shown. For sites with natural groundwater flow, diagrams were presented depicting the width at the top and bottom of the capture zone, the distance between the well axis and the upstream or downstream stagnation point, the maximum distance between two wells between which contaminated groundwater cannot pass without being treated, and the ratio Q_o/Q (upstream discharge in the capture zone/total discharge through the well), which is a measure of the dilution of the upstream inflow and the circulation flow. All the latter parameters, made dimensionless by division through H, except Q_o/Q, are dependent on the ratios Q/H^2v), K_HK_V and a/H. Q denotes the well discharge, H the aquifer thickness, v the Darcy velocity of the natural groundwater flow, K_H and K_V the horizontal and vertical hydraulic conductivities and the length of the screen section.

The advantages of the UVB technology were presented in comparison to a standard pump and treat method and include: (1) no lowering of the ground water level; (2) no groundwater extraction; (3) no wastewater; (4) less permeable, horizontal layers are penetrated vertically; (5) remediation of the groundwater takes place down to the bottom of the aquifer; (6) remediation operation is continuous, even at low well capacity; (7) soil air extraction is possible at the same time; (8) low space requirement; (9) investment and operating costs are considerably lower.

REMEDIATION OF CONTAMINATED SEDIMENTS IN THE NETHERLANDS

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In the 1960s, the Dutch Water Boards were confronted with a deteriorating water quality. Consequently, several actions were taken to reduce the discharge of contaminants, such as heavy metals and organic micropollutants. At the time, it was not realized that not only the surface water, but also the suspended matter and sediment were polluted. Today, however, we are well aware of the sediment being contaminated in many watercourses. In the Netherlands, contaminated sediments are mainly a dredged-sludge problem: many Dutch watercourses must be dredged for nautical reasons and for water management. This means that remediation of contaminated sediments in the Netherlands refers specifically to dredged-sludge remediation. Until a few years ago, all dredged material was disposed of in confined disposal facilities. Recently, treatment technology has been applied to improve the quality of the dredged sludge. Thus, several harbors that were seriously contaminated with PAHs, oil, and metals have been remediated. Their remediation included the dredging and processing of the sludge by classifying and dewatering into a fraction for beneficial use, and into a concentrate for disposal. The WaterBodem Groep Nederland (WBGN = Aquatic Soil Group Netherlands) specializes in dredging and treating contaminated sediments.

Since 1985, technology has been applied to reduce the quantitative volume of contaminated dredged sludge to be disposed. The applied process consists of

include HCl from the reduction of chlorinated organics such as polychlorinated biphenyls (PCBs) and methane and ethylene from reduction of straight-chain and aromatic hydrocarbons. The absence of free oxygen in the reactor prevents the formation of dioxin compounds.

ECO LOGIC has set up a demonstration facility for processing polyaromatic hydrocarbons (PAH) and PCB-contaminated harbour sediments in Hamilton, Ontario, and has been conducting destruction tests during the spring of 1991.

The demonstration-scale reactor is 2 m in diameter and 3 m tall and is mounted on a 15 m drop-deck trailer. A scrubber system and recirculation gas heating system are also mounted on the trailer, as well as the electrical control centre. A second trailer holds a propane boiler and waste pre-heating vessel. The boiler also accepts a small portion of the scrubbed dechlorinated recirculation gas as fuel. The processing rate for the demonstration unit is 4-5 kg/min.

Results from the demonstration testing including destruction efficiencies obtained and processing costs estimates were discussed in the paper. The complete demonstration program will consist of 15 characterization tests of short duration and longer duration performance tests.

DETERMINING THE APPLICABILITY OF X*TRAX™ FOR ON-SITE REMEDIATION OF SOIL CONTAMINATED WITH ORGANIC COMPOUNDS

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Thermal desorption is more and more being considered as a suitable technology for organically contaminated soils. This paper focused on the types of contaminated soils that are likely candidates for thermal desorption. The data presented and conclusions drawn applied only to the patented X*TRAX process developed by Chemical Waste Management, Inc. (CWM).

The various soil characteristics such as soil type, debris, moisture and naturally occurring organic matter that affect performance were discussed. Results from laboratory and pilot scale tests were presented. Typical removal efficiencies for PCB, volatile organics, semi-volatile organics, pesticides and metals were reported. Applicability of the X*TRAX process to industrial wastes such as refinery wastes was also included.

DEMONSTRATION OF FLAME REACTOR TECHNOLOGY

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The HRD FLAME REACTOR high-temperature metals recovery process was demonstrated in March 1991 under the EPA's Superfund Innovative Technology Evaluation (SITE) program on a secondary lead smelter (SLS) rotary kiln "soda" slag from the National Smelting and Refining (NSR) Superfund site in Atlanta, Georgia. The SITE demonstration proved the ability of the FLAME REACTOR process to recover metals in a salable oxide form and to produce a non-hazardous vitrified slag. The detailed cost analysis for the HRD technology is continuing.

Seventy-two tons of the SLS waste were collected, packaged, manifested and shipped to Monaca from the Atlanta site. The waste was then dried and crushed prior to feeding to the FLAME REACTOR process. The natural gas-fired process then subjected the waste to high-temperature (>1500°C) reducing conditions, in a high-intensity, water-cooled furnace, to fume the volatile heavy metals and fuse the slagging materials. The reactor off-gases then passed through a cyclonic separator to remove the molten slag from the gaseous components; the slag was then tapped from the separator and cooled on a vibratory conveyor. The metal fume-laden gases were combusted with air to form a particulate metallic oxide, which was recovered in a baghouse.

During the demonstration, the SLS waste, containing about 8% lead, was converted to oxide assaying at about 20% lead and slag which easily passed the TCLP test. The oxide is recyclable for recovery of lead metal values. The high-sodium content slag exhibited poor physical integrity until silica flux additions were made up to about 20% of feed weight. Extensive sampling conducted during the demonstration test also confirmed that the process stack gas emissions are all well within regulatory limits.

Cost projections based on the demonstration test results for processing the NSR waste and a related stockpile at the Pedricktown, NJ, Superfund site (about 10,000 tons) indicate a net cost of $200-250/ton of raw waste, including drying and crushing, FLAME REACTOR processing, product handling, and sale of the crude oxide. Not included are waste destocking, shipping, and slag disposal. HRD is developing costs for constructing a "transportable" FLAME REACTOR unit for location at various Superfund sites.

ISV cost categories include: 1) treatability testing at engineering-scale ($40-80,000 depending on contaminants and analytical requirements), 2) mobilization and demobilization ($125-200,000 depending on transport distance), and 3) vitrification operations ($300-400/ton depending on price of electricity, amount of water present, and depth of processing). Costs are not included for site characterization, permitting/ARARs compliance, remedial design, site preparation, and other non-direct ISV activities.

The ISV technology is capable of meeting national and state ARARs. It is considered highly protective of human health and the environment, and enjoys excellent regulatory and public acceptance.

ISV technology has been selected as a preferred technology at ten private, EPA-Superfund, and DOD sites.

RAPID REMEDIATION OF A FORMER COKING PLANT SITE

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Within the framework of a risk assessment carried out in 1987, the soil of a coking plant site in Essen, shut down at the end of the 1950s, was found to be heavily contaminated down to a depth of 8 m with coking-plant-specific contaminants (PAHs and BTXs).

The risk potential for soil, air and groundwater was considerable. At the end of 1989, the property owner, the former coking plant operator, commissioned RWE Entsorgung AG to plan and execute the remedial action.

On the basis of a remedial investigation, with the participation of experts and in coordination with the competent authorities, an integrated remediation concept was set up which was used for license application and defined the sequence of the individual remedial steps.

The concept comprised ex-situ remediation, i.e., excavating the soil material (silt and fine sand) layer by layer, and analytically controlled soil classification (uncontaminated or contaminated), as well as decontamination by thermal treatment in the Netherlands.

SANITATION OF THE CRESOL ACCIDENT IN THE AREA SYLSBEK, HIGHWAY A-1, WEST GERMANY

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In January 1989, the driver of a hazardous material transporter spilled about 5,000 liters of ortho-cresol (ortho-methylphenol) onto a parking area of the highway. Two tents were built over the area to reduce toxic gaseous emissions.

Because of the fact that the contaminated soil would not be accepted anywhere, the idea of biological on-site treatment was brought up. ITU got the job of providing concepts, managing and supervising the sanitation. ITU also worked out a feasibility study in which all sanitation and disposal possibilities were discussed. The perferred alternative included disposing of highly contaminated soil at a hazardous-waste dump, mixing the large amount of less contaminated soil with compost and biodegradation on site in ventilated containers.

Circumstances did not allow the start of this solution. Inhabitants and politicians of the area were afraid of this "combination of poison and bacteria" and wanted to have a "fast" possibility to get rid of the problem. But afterwards there were problems with transportation of the material because inhabitants did not want to have any poison trucked through their area. The final decision then was washing highly contaminated soil, packing and disposing all material in gasproof "big bags" and storing it in a hazardous waste dump.

Waste compost filters for the ventilation of the tent were installed and worked more than satisfactorily for the whole time.

After 3 weeks there was evidence of the fact that the contamination of the stockpile was a lot higher than first estimated by the authorities, and the washing

m^3 (12,000 Tons) of polycyclic aromatic hydrocarbon (PAH) contaminated soil were excavated and stored under secure conditions. The storage facility included a concrete pad and plastic cover to prevent release of the contaminants and infiltration of the precipitation, respectively.

This site is under the jurisdiction of The Quebec Ministry of the Environment (MENVIQ). The Plant was ordered by MENVIQ to propose a cleanup technology and to initiate the cleanup by March 1991. MENVIQ required compliance with a list of criteria "B." These criteria (in mg/Kg) limit Mineral Oil and Grease levels to 1000, Naphthalene and Phenanthrene to 5, and total PAHs to 10. Some specific PAHs, assumed or proven to be carcinogenic, are limited to a maximum concentration of 1 mg/Kg.

Due to the heterogeneity of the soil, the screening analysis indicated that these levels for some samples were exceeded.

Several remediation technology options were reviewed before the technology selection was made. Treatment processes were studied and sites visited by the project team.

For studying the feasible remediation options, a pilot scale particle separation study was carried out at Union Carbide's Technical Center. It was hypothesized by the members of the project team that separation of the soil into size fractions would make the treatment simple, and could possibly reduce the volume remaining for washing and/or off-site disposal. Thus, a sequential combination of size separation, washing, and treatment/disposal technologies offered a viable, low-cost management option.

Based on the results of the laboratory, pilot, and field experiment, a full scale soil treatment process was designed and implemented. The full scale implementation of the project was contracted to Lavalin Envirotech Inc. of Montreal, Quebec.

A major problem has occurred at the site because the treated material becomes "quick" when water is applied. One can walk across the material but slight vibrations result in loss of bearing strength. The reasons for the "quick" conditions are still being investigated. Whatever the reason, the treated material cannot be used as backfill as originally conceived.

As to the applicability and effectiveness of the process used at Wide Beach, conclusions cannot be totally drawn until all the costs have been accounted and a total review of the data performed. The treatment system appears to be reducing the PCB levels to undetectable levels in the soil (approximately 4 ppb).

BIOREMEDIATION DEMONSTRATION AT THE COAST GUARD FACILITY, TRAVERSE CITY, MICHIGAN

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The efficacy and relative costs of three distinctly different approaches for bioremediation of fuel spills have been evaluated at a U.S. Coast Guard Air Station in Traverse City, Michigan. The water table aquifer underlying the Air Station is in medium sand. Two large plumes emanate from an aviation gasoline spill and a jet fuel spill.

A portion of the spill of aviation gasoline was remediated using conventional practice with hydrogen peroxide 500 to 1,000 mg/L. A portion of the spill of JP-4 jet fuel was remediated using innovative technology that supplied nitrate as an electron acceptor for microbial metabolism 40 to 50 mg/L. Another portion of the aviation gasoline spill was remediated through bioventing. Bioventing is a modification of vacuum extraction that uses biodegradation in the unsaturated zone to destroy the vapors recovered during vacuum extraction. Bioventing was applied to an area of the aviation gasoline spill where most of the fuel was trapped in the capillary fringe above the water table. The rate of injection allowed 8 to 24 hours residence in the unsaturated zone before the air vented to the atmosphere.

All three technologies successfully reduced the concentration of carcinogenic alkylbenzenes in groundwater below federal drinking water standards. Air emissions from the demonstrations were acceptable. However, none of the technologies reached total petroleum hydrocarbon standards (e.g., 10 to 100 mg/kg)

as 1.439 mg/l. Other parameters encountered during site investigations are as follows:

Parameter	Maximum Value Identified
NH^3	118 mg/l
TKN	121mg/l
NO^3	13.8 mg/l
TSS	1510 mg/l
P	17.8 mg/l
pH	Between 3 and 8 Units

Various metals were also encountered in the landfill leachate. Specific metals of concern included arsenic, chromium, copper, cyanide, lead, mercury, and zinc. The concentration of these metals was generally minor, typically lower than 50 parts per billion. The treatment plant was provided with enforceable discharge limits by the State of Ohio.

Operation of the treatment plant consists of chemical precipitation for metals contained within the influent stream, followed by biological treatment for the organic, biodegradable portion, and activated carbon for the refractory organics.

FIELD DEMONSTRATION OF ENVIRONMENTAL RESTORATION USING HORIZONTAL WELLS

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Under sponsorship from the U.S. Department of Energy, technical personnel from the Savannah River Laboratory and other DOE laboratories, universities and private industry have completed a full scale demonstration of environmental remediation using horizontal wells. The 139 day long test was designed to remove volatile chlorinated solvents from the subsurface using two horizontal wells. One well, approximately 90m long and 45m deep drilled below a con-

3. The operational problems of the waste water treatment in the large chemical industry facility connected with the bulking of activated sludge resulted after laboratory tests in the modification followed by the spontaneous carbonation. The efficiency of the biological step increased from 75 to 95 percent (BOD_5); the carbonated sludge connecting microcrystals of calcium carbonate improved its settling and dewatering properties totally. The leachate properties of the sludge - the mobility of heavy metals (zinc, mercury) - decreased. The improved efficiency has been achieved on the account of the higher operational costs, but not more than by 3 percent (lime is being used for the neutralization of waste water in flow in any case).

CATALYTIC OXIDATION FOR EMISSIONS CONTROL OF SITE REMEDIATION ACTIVITIES

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The presentation summarized the results of three field tests using catalytic oxidation for emissions control. The remediation activities are pilot- and full-scale testing of air stripping and also a pilot scale soil vapor extraction system test. Costs of catalytic oxidation vary from one-ninth to more expensive than activated carbon for emissions control options for the different remediation processes. The catalytic oxidation process is extremely dependent on not only the contaminants and their concentrations, but also any poisons that may be in the airstream. It is well known that different catalyst chemical formulations are neded for different target contaminants to be oxidized. However, different reactor types may also be needed (i.e., a fluidized bed for higher concentrations, or with particulates in the air stream). Information on the long run operation of a fluidized bed catalytic oxidation unit used to clean 1200 cubic feet per minute of trichloroethylene contaminated air from an air stripping operation was also presented.

To support the field activities the Air Force has been working in two areas. The first area includes development of poison-resistant catalysts. Two formulations have shown promise at the lab scale. The second area includes development of a catalyst testing and selection protocol to ensure the optimum catalyst is used for a given waste stream. A field test of the protocol and the new catalyst formulations is planned for May 1992 when the Air Force will test a new air

Waste compressed gas cylinders represent one of the most hazardous waste materials. Potential hazards include all those which are associated with other chemical wastes. Additionally, there are hazards associated with the energy of compression and the mobility of the materials when released.

Containers used to store compressed gases can also compound management problems. Cylinders that have been mishandled, incorrectly labeled, or otherwise inappropriately stored may no longer be structurally capable of containing the gas during handling. In addition, valves may become damaged or inoperable through misuse.

Additional concerns include the use of the contents and cylinder. Research facilities will often use common manifolds that may not restrict backflow due to differential pressures. Dangerous combinations of gases may result. Nonstandard cylinders may have been used to store incompatible gases. In addition, some gases or mixtures may chemically decompose over time, creating unstable mixtures within the container.

Historical management methods have included burial, uncontrolled release, detonation, valve actuation in a pressure vessel, and cold and hot tapping, among others. Each of these methods does not provide sufficient engineering controls to eliminate potential uncontrolled releases, exposures to physical and/or chemical hazards, or contingencies for valve or cylinder failure on- site.

Methods for safely managing compressed gas cylinders begin with a simple decision analysis to correctly classify cylinders. Following the analysis, the appropriate methodology may be employed to safely manage these cylinders. Techniques are available to provide disposal for even the most difficult cylinder to manage: a cylinder in an advanced state of corrosion, with a nonoperable valve and unknown contents.

Methods to safely and successfully manage compressed gas cylinders have been successfully employed at Superfund and federal agency sites. The paper discussed case histories, defining the problem, evaluating the hazards, and illustrating the actions used to safely identify, dispose, or treat these cylinders.

test unit it was estimated that a full-scale unit would necessarily be set at a power dosage of 0.67 KW/gpm to achieve treatment objectives at the design condition.

The extraction wells and treatment plant were completed in November 1989. Since the extraction was started in November of 1989, the lateral extent of contaminant has been reduced. The treatment plant has operated with effluent TCE at or near the detection limit. Power dosage in the field has generally varied from 0.3 to 1.0 KW/gpm and hydrogen peroxide residuals (i.e., the measured H_2O_2 in the effluent of the reaction chamber) have varied from about 8 ppm to over 20 ppm.

Only limited data has been gathered to date at this site. The results should be considered site-specific and not extrapolated for other situations.

DEVELOPMENT OF BIO-SCRUBBER FOR REMOVING HAZARDOUS ORGANIC EMISSIONS FROM SOIL, WATER AND AIR DECONTAMINATION PROCESSES

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The "bio-scrubber" concept was identified by Alcoa Separations Technology Inc. (ASTI) in 1989 as an innovative emission control technology for airborne volatile organic carbons (VOCs). The concept combines thin-film microbial decomposition and traditional granular activated carbon (GAC) adsorptive processes on a proprietary support media. ASTI proposed development of the bio-scrubber through an EPA cooperative agreement under the Superfund Innovative Technology Evaluation (SITE) Program in January 1990.

The development project includes five major tasks:
1. Laboratory feasibility determination (completed)
2. Bench-scale operating parameter evaluation (in progress)
3. Engineering evaluation
4. Superfund site selection
5. Economic analysis and commercialization plan development

Feasibility of the technology was demonstrated in 1989 during preliminary lab studies, which indicated that the addition of specific microbial cultures to a

provide a very high removal rate when they are coupled with ASESs patented immobilized cell support system.

The basic ICB system consists of the i) bioreactor, ii) media and microbes, iii) nutrient mix tank, iv) feed pump, and v) blower for aerobic system. There are no moving parts within the reactor. The blowers, pumps and electrical equipment are located in a dry, protected area adjacent to the reactor.

ICB Systems range in capacity from 2000 GPD to over 300,000 GPD. The system is modular and can be expanded inexpensively to meet your growing needs.

High treatment capacity of an ICB system provides the benefits of easy installation, low capital cost, minimum operating and maintenance cost.

ASES provides a full range of technical services to assure best possible treatment system for your short and long term needs. We have developed an extensive series of laboratory treatability tests and field pilot equipment to simulate full scale operation of treatment processes and equipment. These procedures are based on our thorough knowledge of water treatment processes and design. Inexpensive laboratory tests can produce design information quickly and economically, while our field pilot equipment subjects our designs to the real-world rigors of your treatment requirements. Together or separately, these services can provide you with the extra margin of safety required on critical projects, and the assurance that your treatment system will work right the first time.

PYROKILN SYSTEM THERMAL ENCAPSULATION PROCESS

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Allis Mineral Systems is developing the PYROKILN System Thermal Encapsulation Process under the EPA Emerging SITE Program. The goal is to trap toxic metals in a controlled melting process while incinerating organic wastes.

This research, development and demonstration program builds upon work done in past industrial minerals and hazardous waste systems. Phase I of the project

METALEEP^{sm} - THE TOTAL SOLUTION FOR ON-SITE REMEDIATION

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The Low Energy Extraction Process (LEEP^{sm}) is a patented continuous solvent extraction process for on-site remediation in which hydrophobic organic contaminants (HOC) are removed from solid matrices. While the process was originally designed to remove polychlorinated biphenyls (PCBs) from sediments, it has been shown, both theoretically and experimentally, to have much broader applications. Some of the most notorious organic pollutants that can be removed in addition to PCBs are: petroleum hydrocarbons (PHC), polyaromatic hydrocarbons (PAH), pesticides, wood preserving chlorophenol formulations and tars removed (leached) from contaminated soils, sediments and sludges.

ART International has developed an analog to LEEP^{sm} called METLEX^{sm} which can be used to extract metals from a contaminated solid stream. METLEX^{sm} can be combined with LEEP^{sm} to remove both organic and metal contaminants. The combined process is called METALEEP^{sm}. METALEEP^{sm} consists of trailer mounted process modules in which the organic and inorganic leaching solvents are internally recycled while the contaminants are concentrated for disposal. In some instances, metals can be recovered for by-product value. Cleaned solid can be returned to the environment.

The METALEEP^{sm} process scheme consists of organic decontamination (LEEP^{sm}) followed by metals clean-up (METLEX^{sm}). The process is applicable to a wide range of solid matrices containing particle sizes down to the submicron range and having water concentrations from a few percent up to 90%+. The leaching process is carried out in a counter-current contactor. Fresh (organic or inorganic) leaching solvent enters one end of the device while contaminated solids enter the opposite end. The contaminants are transferred from the soil to the solvent by virtue of mass transfer driven by solubility, concentration gradients and partitioning effects.

The METALEEP^{sm} technology can be used to remove a wide range of hydrophobic chemicals in combination with metals from contaminated solids. By prudent choice of solvents, cosolvents and flow rates of solid and liquid streams, the process can be used to clean up contamination such as refinery

bench-scale and pilot-scale, and finally with a skid-mounted mobile unit. Results obtained from various tests have indicated successful removal of dissolved cadmium, mercury and lead from solution.

The AECL process involves contacting contaminated aqueous solutions with a water-soluble polyelectrolyte. Size enlargement of the metal ions arises by forming selective "metal-polyelectrolyte complexes" at specific pH and temperature conditions. The polyelectrolyte quantities needed to achieve the desired size enlargement and hence the separation of metal ions are generally in the part-per-million range. Once the desired size for the metal complex is achieved, the solution containing the complex is then processed through a cross-flow ultrafiltration membrane. The membrane system retains the complexes as a concentrate stream, while allowing uncomplexed ions to pass through the membrane with the filtered water. The filtered water is recycled, or discharged depending on the goal set out for metal contaminant removal. The sole residue generated by the process is the ultrafiltration concentrate. The concentrate generally constitutes 5 to 20 percent of the feed volume. Once the target concentration is reached, the concentrate stream is withdrawn for further treatment, after which it can be readily solidified and safely disposed.

The mobile ultrafiltration unit is capable of providing filtered water rates of up to 8 gpm. The unit has undergone testing at Chalk River Laboratories. Preliminary field trials with the unit were completed at a uranium mine tailings site. The unit is currently available for treatability/demonstration tests for contaminated groundwater and leachate.

B&W CYCLONE FURNACE FOR WASTE VITRIFICATION

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The Babcock & Wilcox cyclone vitrification furnace appears well suited to treating high inorganic content hazardous wastes (e.g., solids) which exist at many Superfund sites. In the first phase of a study performed under the U.S. EPA Superfund Innovative Technology Evaluation (SITE) Emerging Technologies Program, the B&W 6 million Btu/hr pilot cyclone furnace was used to vitrify an EPA Synthetic Soil Matrix (SSM). The SSM was spiked with 7,000 ppm

TCE and related compounds pose a new challenge to biological treatment because, unlike non-halogenated aromatic hydrocarbons (BTEX), for example, they cannot be used as primary substrates for growth by bacteria. Their degradation depends upon the process of cometabolism which is attributed to the broad substrate specificity of certain bacterial enzyme systems. Aerobically, many enzyme systems have been purported to cooxidize TCE, but the methane monooxygenase (MMO) of methanotrophic bacteria, because of its favorable kinetics, has the most promise.

For more than four years, BioTrol has supported research at the University of Minnesota under Richard Hanson and Lawrence Wackett on methanotrophic degradation of halocarbons. Although it is known that MMO can be expressed in two different forms (soluble or membrane-bound), BioTrol-sponsored research has shown that the soluble form is responsible for extremely rapid rates of TCE degradation. (Stemming from this work, BioTrol has a process patent pending.)

The goal of this Emerging Technology project is an innovative bioreactor which effectively exploits these rapid degradation rates. Continuous-flow, bench-scale experiments have been conducted during the first year, and the data collected justify proceeding to the pilot scale. Design, fabrication and field testing of a 1 gpm system is planned for the second year of the project.

BIOGENESIS^{sm} SOIL CLEANING PROCESS TECHNOLOGY SUMMARY

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BioGenesis is an ex-situ extraction technology which washes soil using a complex bioremediating surfactant and water. The process is capable of extracting volatile and non-volatile oils, chlorinated hydrocarbons, pesticides, and other organics from most types of soil including clays. Throughput ranges from 20 to 35 tons per hour depending on contaminant, contamination level, and soil type. Costs range from $60 to $180 per ton for oils. Hazardous chemical cleaning costs are higher.

X*TRAX™ - TRANSPORTABLE THERMAL SEPARATOR FOR ORGANIC CONTAMINATED SOLIDS

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The remediation of solids such as soils, filter cakes and pond sludges that are contaminated with organic chemicals is a major problem for the environmental industry. Many of these wastes can be treated using a thermal separator; essentially, by drying them. Chemical Waste Management (CWM) has developed a patented system, trademarked X*TRAX™, that thermally separates organics from solids in an indirectly heated rotary dryer. The volatilized organics and water are carried to a gas handling system with an inert gas (nitrogen) where they are condensed and collected as a liquid. The carrier gas is reheated and recycled to the dryer in a closed loop. Only a small portion of the carrier gas is vented to atmosphere through carbon adsorbers to control noncondensables in the recirculation loop. CWM has constructed a full scale transportable thermal separator with a nominal capacity of 125 tons per day. This unit has been contracted for treatment of PCB-contaminated soils at the Resolve, Inc. Superfund site in Massachusetts. CWM has been operating both a 5 ton/day pilot system and a 2-4 lb/hr lab scale system since early 1988. The pilot unit has performed extensive testing on TSCA wastes in 1989 at CWM's Kettleman Hills Facility in central California, and is presently testing RCRA wastes. The laboratory unit is available for treatability testing.

aluminum hydroxides; phosphate is removed as the insoluble aluminum phosphate species.

Alternating current electrocoagulation is foreseen either as a primary treatment technology (for example, for suspended solids removal) or as a "polishing" technology for effluents to which chemicals (alum, lime) had previously been added for gross contaminant reduction. The technology is effective in reducing the volume of a potentially hazardous slurry by concentrating the clays and metals into a readily dewaterable and filterable solid phase. Electrocoagulation offers equivalent or slightly better treatment than chemical polymer addition and has the added attributes of producing more readily filterable sludges without introduction of soluble species. In terms of solids and metals reductions, the results achieved by electrocoagulation are far superior to those achieved by alum addition.

LASER INDUCED PHOTOCHEMICAL OXIDATIVE DESTRUCTION OF TOXIC ORGANICS IN AQUEOUS STREAMS (LIPOD)

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Organic compounds and specifically chlorinated aromatic and unsaturated organics are major contaminants in groundwaters. These latter species also tend to rank high on the list of EPA priority pollutants, even at the low (g/l) concentrations that they are normally found in groundwaters. The technology described in this report has been developed under the Emerging Technologies section of the Superfund Innovative Technology Evaluation (SITE) Program to photochemically oxidize organic compounds in wastewater by applying ultraviolet radiation using an excimer laser. The photochemical reaction is capable of producing the complete destruction of moderate to extremely low concentrations of toxic organics in water. The energy supplied by the laser is sufficient to stimulate photochemical reactions between the organics and hydrogen peroxide employed as a chemical oxidant, causing photo-oxidation and/or phototransformation of the toxic species to carbon dioxide, water, and the corresponding halogenated acid. Additionally the radiation is not absorbed to any significant extent by the water molecules in solution. The process has

During the drilling operation, the auger flights break the soil loose allowing the mixing blades to blend the reagent(s) and the soil into a homogeneous mixture. As the auger advances to a greater depth, the soil and reagent(s) are remixed by an additional set of augers and mixing blades located above the preceding set on each shaft. When the desired depth is reached, the augers are reversed and withdrawn and the mixing process is repeated on the way to the surface. Left behind is a homogeneously treated block of soil. Each treated block of soil is composed of two overlapping columns. The pattern of columns is extended laterally in rows of treated blocks, in a repetitive manner to encompass the total area of the required remediation. The depth of the columns, which can exceed 100 feet, encompasses the vertical extent of the remediation.

TWO-STAGE FLUIDIZED-BED/CYCLONIC AGGLOMERATING INCINERATOR

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Under the joint sponsorship of U.S. Environmental Protection Agency, Gas Research Institute, and IGT's Sustaining Membership Program, the Institute of Gas Technology (IGT) is developing a natural-gas-based two-stage incineration (TSI) technology for the remediation of contaminated soils at the Superfund sites. Although initially targeted for this limited application, the technology holds a promise for much broader application for the disposal of such wastes as municipal solid wastes, pulp and paper mill sludge, non-metallic automotive

IT is testing this treatment process on a PCB contaminated soil and TCDD contaminated soil. The soils are photolyzed using both natural sunlight and artificial UV light for comparative purposes. The effects of adding a photolysis-enhancing surfactant to the soils is also being evaluated. Biodegradation is being evaluated on the photolytically-transformed PCB contaminated soil only. This is because typical TCDD contamination in soils is in the low to mid parts per billion range which makes tracking and quantitation of any photolytically transformed contaminants difficult.

The combined technologies of photolytic decomposition followed by biodegradation of residuals offer promise of a cost-effective politically acceptable solution for contaminated soil. A primary feature of this technology combination is the possibility of treating applicable soils in-situ. It is an alternative to the conventional methods of treating those soils – dig and haul, which is contrary to the goals of Superfund, and thermal incineration which encounters significant resistance to acceptance from environmental groups and the public. It is also an alternative to emerging technologies such as soil flushing, soil extraction and KPEG treatment.

Other attributes of this technology combination are relative ease in setup of equipment, use of conventional earth moving equipment, no air emissions, processing at ambient temperatures and minimal and innocuous residuals. All of these features make this technology combination very attractive to the Superfund program.

The primary area of application of this technology is sites with relatively shallow contamination where in-situ treatment involving tilling of the soil and surface photolysis can be effective. The experimental program proposed for this evaluation and demonstration will yield data that can also be used for application to sites where the soil is excavated and treated in a land treatment type unit (spreading contaminated soil on ground for treatment).

This technology combination is expected to be especially cost-effective for smaller sites where per unit treatment costs are typically high. Higher costs at these smaller sites are the result of high fixed costs (mobilization, demobilization, capital recovery) associated with other treatment technologies. This in-situ treatment capabilities of this technology will eliminate many of these high fixed cost factors and provide a viable alternative to the "dig and haul" treatment option.

Therefore, these coupled technologies will have the added benefits of greater acceptability and lower risk in remediation decisions.

THE AIR-SPARGED HYDROCYCLONE: A DEVICE FOR RECOVERY OF METAL VALUES FROM MINING WASTES

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The Air-Sparged Hydrocyclone is a recently-developed flotation machine which is especially suited to the recovery of fine mineral particles through the froth flotation process. The device is currently being tested at the Montana Tech Research Center in Butte, Montana, to evaluate its efficacy in the separation and recovery of metallic minerals from mining/milling wastes.

Froth flotation is presently the primary method for separating metallic minerals from their ores. It may also be applied to the extraction of mineral values from wastes which were laid down at a time when mineral processing technology was less advanced than it is today and significant amounts of presently-recoverable mineral values remained in the waste (tailings) remaining after mineral processing.

In the flotation process, certain of the minerals in aqueous slurry are rendered water repellent through contact with organic chemicals, which are termed "collectors". Other minerals remain water wetted. In the presence of moving air bubbles, the water repellent minerals adhere to the bubbles and are levitated to the surface of the slurry, where they are skimmed off. As a result of the reduced inertia of small particles, the flotation process diminishes in efficiency as particle size decreases, resulting in high concentrations of otherwise floatable particles 50 micrometers in diameter or smaller.

The Air-Sparged-Hydrocyclone (ASH), which was developed at the University of Utah by Dr. J. D. Miller, promises improved flotation recovery of small particles through two features, both of which increase the probability of mineral/bubble collision and adhesion:

1) Introduction of air through a porous membrane produces a very high concentration of bubbles.

The hydrocarbons and water in the dirty water storage tank are pumped to a centrifuge, where the hazardous hydrocarbons are spun out into a pasty sludge ready for final disposal. This process concentrates the contaminants, which are typically one-half of one percent of the total incoming mass.

The water is then pumped through a potable water filtration system which includes a depth filter, a water clarifier, and two stages of activated carbon. The water is pumped to the clean water storage tank where it is tested to assure it is clean.

The cleansed material, less a pound or so per ton of concentrate, can be returned to the excavated site or recycled back into the marketplace.

SAREX CHEMICAL FIXATION PROCESS (SAREX CFP)

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The SRS "SAREX CFP" Chemical Stabilization and Solidification process provides lime-based chemical fixation of hazardous organic and inorganic sludges. The lime is specially prepared and contains proprietary nontoxic chemicals that catalyze and control the reactions between the lime and the waste. Results are better than competing fixation processes because chemical reactions change and bind the hazardous constituents. The technology has been demonstrated at commercial sites and the vendor is experienced in commercial application.

The process has been developed over a number of years to be applicable to a broad spectrum of organic and inorganic wastes. This has proven to be advantageous since most on-site clean up programs focus on a sludge pond or impoundment that has received many different wastes over several years. Oily sludges and organic chemical sludges are particularly suited to the technology. Few, if any, fixation-type technologies actually provide the chemical bonding of organics that is achieved by the SRS technology. Inorganic sludges and wastes can be handled by the technology as well. Metals are captured in the treated matrix and have been shown to pass the TCLP test.

Inc. has developed an inorganic chemical complexing agent (RHM-1000) that will remove heavy metals and/or radionuclides from industrial waste water, pond water, ground water, or container water.

Laboratory and field test data have demonstrated that RHM-1000 efficiently complexes essentially all the heavy metals and NORM and man-made radionuclides. RHM-1000 yields high Decontamination Factor values as a flocculation agent, and is also efficient when used as a filter bed material to remove pollutants existing as colloids, colloidal aggregates, and submicroscopic particles that escape conventional filters.

RHM-1000 is currently being tested for use as a colloid or polishing filter. Engineering and field tests are being conducted for the purpose of:

1) evaluating removal of heavy metals from industrial waste waters

2) removal of NORM from uranium mining water, ground water and remediation of man-made radionuclides

The methodology has application for remediation of heavy metals or radionuclide contaminated water and can be used in conjunction with soil and sludge washing methods.

TECHNOLOGY SUPPORT CENTER THE ROBERT S. KERR ENVIRONMENTAL RESEARCH LABORATORY

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The Superfund Amendment and Reauthorization Act (SARA) directs the U.S. Environmental Protection Agency (EPA) to conduct a program of research, evaluation, and demonstration of alternative and innovative technologies for remedial response actions that will achieve more permanent solutions. Individuals making decisions concerning remedial action options must select and/or approve effective remediation activities and technologies for each specific site that will be protective of human health and the environment.

SUBSURFACE REMEDIATION TECHNOLOGY DATABASE: A SUPERFUND TECHNICAL ASSISTANCE TOOL

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The Subsurface Remediation Technology (SRT) Database is a program designed to provide site specific information concerning subsurface contamination and remediation activities presently being conducted or proposed at Superfund sites throughout the United States. The target audience for the SRT Database includes: EPA Scientists, Remedial Project Managers, On-Scene Coordinators, Superfund site contractors, and other key federal and state personnel associated with subsurface contamination and remediation activities. The purpose of the database is to provide a single comprehensive source of information which can be shared and compared to other sites having similar problems or scenarios. The SRT Database consists of five related components: site characterization, methods of remediation, contaminants, consulting firms, and references cited.

The site component serves as the core and has a one-to-many relationship with the other components and includes historical notes, descriptions of the contaminants, soil, geology and hydrogeology, alternative remediation methods considered, and the names of EPA Regional personnel associated with the sites.

The SRT Database allows searching for over 60 contaminants which are most frequently found at hazardous waste sites. These represent contaminant classes, including: metals, pesticides, chlorinated solvents, polynuclear aromatic hydrocarbons (PAH), hydrocarbons and derivatives, and a general class composed of such contaminants as cyanide, pentachlorophenol, and vinyl chloride.

The SRT Database also allows searching based on the type or types of remediation technology being applied at a site. The technologies included range from the passive, such as barriers, drains, and covers, to the active, such as pump and treat, in-situ biological, and soil vacuum extraction.

TREATMENT OF NITROAROMATIC RESIDUES IN SOIL: A NOVEL ANAEROBIC PROCESS

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Nitroaromatic compounds are used in the agricultural industry as herbicides, in ordnance manufacturing and as precursors in a variety of chemical industry processes. These compounds have become serious environmental contaminants throughout the world, and methods for their removal from soil and water are needed. Compounds with more than one nitro group have not been shown to be mineralized aerobically or anaerobically. Initial microbial transformations that have been observed usually involve the reduction of nitro groups to amines. Reduction continues, forming hydroxylamine intermediates. Under aerobic conditions, these intermediates react with one another and undergo nonenzymatic oxidation to form azoxy bonds. Such polymeric compounds bind to soil organic matter and have been found, in some cases, to be more mutagenic than their parent compounds. We are investigating an anaerobic biological treatment process for soils contaminated with nitroaromatic compounds. A complete remediation process has been developed for soils contaminated with dinoseb (2-sec-butyl-4,6 dinitrophenol) and a similar process for TNT (2,4,6 trinitrotoluene) contaminated soils is under investigation.

The major advantages of this treatment process over other advanced oxidation processes are:

1. Approximately equal concentrations of reducing species, e^-_{aq} and $H\cdot$ and the oxidizing specie $OH\cdot$ are formed at the same time in solution. This allows for the simultaneous treatment of complex mixtures of hazardous chemicals.

2. The reaction of the reactive species with most organic chemicals is very rapid allowing a continuous flow through treatment process of various water qualities, including streams with suspended sediment or suspended solids in amounts up to 8 to 10 percent. Removal is less affected by water quality in this process than in other processes.

A TRANSVERSAL FLOW PERVAPORATION SYSTEM FOR THE REMOVAL AND CONCENTRATION OF VOLATILE ORGANIC COMPOUNDS

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Pervaporation is a new membrane process for the removal and concentration of volatile organic compounds (VOCs) from contaminated water. This process can be used to treat groundwater, leachate and wastewater containing VOCs such as chlorinated solvents. About half of the 129 US EPA priority pollutants are VOCs and are known to be toxic and/or carcinogenic.

In pervaporation, one side of a dense, polymeric membrane is in contact with water containing organic compounds, while the other side of the membrane is exposed to a vacuum. Organic compounds and water are absorbed in the membrane and diffuse through to the other side where they are drawn off by a vacuum. Materials passing through the membrane are contained by condensation.

The membrane is made of an organophilic polymer which exhibits high fluxes for the organic compounds while allowing very little permeation of water. Organic compounds are concentrated in the condensate by orders of mag-

oxidation that occurs at elevated temperature and pressure. PACT, when coupled with WAO, provides complete destruction of many toxic components and reduces sludges to a stable, sterile, inorganic residue.

As part of the SITE demonstration, contaminated groundwater from the Syncon Resins Site in Kearny, New Jersey, was treated at the Zimpro Passavant Testing and Development facility (a permitted hazardous waste treatment, storage, and disposal facility, No. WID044393114) in Rothschild, Wisconsin. All eleven priority pollutants in the groundwater were reduced to below detection limits. Unfortunately, the Syncon Resins Site was not available for the full-scale demonstration. EPA is continuing to search for a suitable site.

WAO systems have recently been employed in Belgium, Taiwan, Texas, and Louisiana in the destruction of sulfide and organics accumulations in caustic scrubbing liquors. WAO systems have been tested and are currently being built for treatment of pharmaceutical production wastewaters in the United Kingdom as an alternative to disposal in the North Sea. PACT systems have recently come on-line for treatment of process wastewaters in Korea, India, Canada, and in several locations in the United States.

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