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UV Radiation & Reverse Osmosis Combine to Treat Complex Wastestreams

Metals and organics
Reverse osmosis/ UV radiation
Landfill leachates

by Andre Zownir, Environmental Response Team, Edison, New Jersey & Lou DiGuardia, On-Scene Coordinator, Region II

Modern reverse osmosis (RO) technology has been applied to treat complex wastewaters, chemical spills and landfill leachates. Although effective for removing most heavy metals, RO has not proved particularly effective for organic compounds. But recent pilot tests at the Pollution Abatement Services Superfund Site (PAS) in Osego, New York, added ultraviolet (UV)/ ozone/hydrogen peroxide oxidation pretreatment to the RO process and successfully removed many of the organic compounds.

The purpose of the RO/UV study was to determine if these alternative technologies were effective enough to avoid the time, money and manpower to pump, transport and dispose of leachate at an off-site treatment facility. At the PAS site, it was also necessary to couple RO/UV with other on-site treatment technologies.

All leachate was pretreated prior to RO/UV treatment. The first objective of the pretreatment was to reduce the iron content in the leachate by the addition of sodium hydroxide to separate out the iron in solid form. Conversely, the second objective was to increase the solubility of the remaining metals by adding acid so that: (1) the metals did not solidify inside the 2,000 liter reverse osmosis feed tank, thus causing damage to the membrane used in the RO process; or (2) during the UV oxidation process, thus causing scaling on the quartz shield protecting the UV lamp.

Reverse osmosis separates low molecular weight solvents, like water, from dissolved solutes (in this case, metals) using a semi-permeable membrane that allows permeation of the solvent while rejecting the solutes. The driving force for solvent transport across the RO membrane is pressure. Therefore, to achieve separation, only pressure is needed—eliminating the costly phase separations found in distillation, evaporation and crystallization technologies.

An Environment Canada mobile RO unit was used to carry out the reverse osmosis separation of PAS leachate. Pretreated leachate was fed into the osmosis system under high pressure. Semi-permeable membranes inside the unit separated the leachate into two streams, permeate and concentrate, and rejected the metals from the streams. The concentrate stream went to a holding tank for processing by ultraviolet oxidation.

(see Reverse Osmosis, page 2)

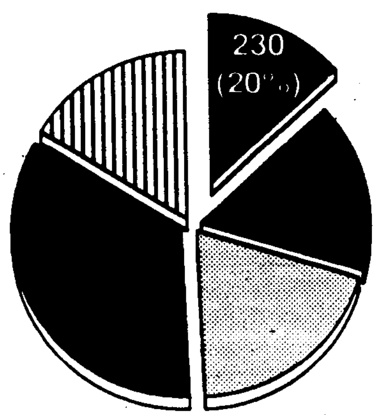
U.S. Army Joins EPA

The U.S. Army joins EPA as a contributor to Tech Trends

To meet the challenge of cleanup of Superfund sites at federal facilities, the U.S. Army Toxic and Hazardous Materials Agency is devising innovative ways to treat wastes on site.

In this issue of Tech Trends Cpt. Craig Myler tells us about an innovative Low Temperature Thermal Stripping process to treat soil contaminated with cleaning solvents and fuels. The process expends less energy and is lower in cost than incineration. Don't pass up Cpt. Myler's article on page 3.

ATTIC: Biological Treatment



The Alternative Treatment Technology Information Center Database contains 230 citations on Biological Treatment.

See "Out of the ATTIC" on page 3 for one user's experience.

Reverse Osmosis

(from page 1)

The permeate stream, now clean water, was injected into the landfill. Overall, RO works well in concentrating heavy metals with membrane rejections usually above 95%, with the exception of lead, selenium and zinc. For example, arsenic concentrations were reduced from 54 parts per billion (ppb) to 2.2 ppb and nickel concentrations from 2580 ppb to non-detectable levels.

Now for the UV process: Ultraviolet oxidation is super-oxidation by an oxidizing chemical, usually ozone or hydrogen peroxide, in the presence of ultraviolet light. The technology's successful treatment of various organic-laden waste waters made it a good candidate for PAS leachate treatment. Both the RO permeate and concentrate leachates were fed to the UV system where the combination of ultraviolet energy, ozone and hydrogen peroxide destroy the organic constituents. The UV effluent was then sent for surface discharge or reinjection to the landfill; this achieved a further leachate contaminant reduction in the landfill since, ideally, the effluent stream contains decontaminated water. At PAS, the UV unit provided by Solarchem contained three upflow reactors in series with separate ozone, hydrogen peroxide and acid/base addition ports near the entry to each reactor. The system controlled pH and ozone and hydrogen peroxide additions. An ozone generator provided the unit with the necessary oxidant.

UV treatment, by batch runs rather than continuous runs, was able to lower most organic contaminant concentrations in leachate and RO permeate to dischargeable levels. However, a notable possible problem was the residual acetone content. Methylene chloride concentrations were reduced from 143 ppb to non-detectable levels and nitrobenzene concentrations from 251 ppb to 4.4 ppb during 90-minute runs.

From the data at PAS, models were constructed to assist in the evaluation and prediction of reverse osmosis performance at this and other hazardous waste sites. The pilot tests at PAS also gleaned information on which of various membranes would be best at your site.

For more information, call Andy Zownir of the EPA Environmental Response Team in Edison, New Jersey, at FTS-340-6744 or 908-321-6744 or call Lou DiGuardia in Region II at FTS-321-6712 or 908-321-6712.

SITE Subjects

Vacuum Steam Stripping Combined with Vapor Extraction Produces No Air Emissions

VOCs
Vacuum steam stripping/vapor extraction
Groundwater/soil

by Gordon Evans, Risk Reduction Engineering Laboratory

For the past two years, AWD Technologies, Inc., has been operating their AquaDetox/SVE system at the San Fernando Valley Superfund Site to remediate groundwater and soil contaminated with volatile organic compounds (VOCs). The Site is at a Lockheed Aeronautical Systems facility in Burbank, California. During September 1990, EPA demonstrated the AquaDetox/SVE system as part of the Agency's Superfund Innovative Technology Evaluation (SITE) Program.

The process is an automated system that combines a vacuum assisted steam stripping tower (the "AquaDetox" unit) with a closed loop soil vapor extraction (SVE) unit. The beauty of the system is that it cleans contaminated groundwater and soil gases within a closed loop, thus eliminating air emissions.

Groundwater contaminated with VOCs enters the top of the AquaDetox unit stripping tower. Under a moderate vacuum, steam is injected at the bottom. Within the tower, the organics are stripped from the water, condensed and collected for recycling. The SVE unit removes contaminated soil gases from the vadose zone through a network of extraction wells. These soil gases are then exhausted through two separate granular activated carbon (GAC) beds for hydrocarbon removal. The cleaned gases are reinjected into the ground.

Among the innovative design features is the periodic regeneration of the GAC beds for continual reuse. The AquaDetox/SVE system is designed with three independent GAC beds in series. Two GAC beds are always on-line for cleansing soil vapor gases. The remaining bed is taken off-line and steam is injected through it stripping off hydrocarbons. This vapor is then sent back to the AquaDetox unit, where the organics are separated, condensed and recycled. In addition, an automated process control unit continuously monitors and adjusts the operation of the entire AquaDetox/SVE system. As a safety feature, the process control unit will shut the system down when it senses deviations from its normal operating parameters.

At the time of testing, the AquaDetox/SVE system was treating groundwater contaminated with as much as 2,200 parts per billion (ppb) trichloroethylene (TCE) and 12,000 ppb tetrachloroethylene (PCE) and soil gas with a total VOC concentration of 450,000 ppb. Preliminary results suggest that groundwater contaminants ar reduced to virtually non-detectable levels, with soil gas contaminants reduced to about 350 ppb. Groundwater is being treated at a rate of 1,000 gallons per minute, while soil gas is treated at a rate of 200 cubic feet per minute. During two weeks o EPA's testing, gas and water samples were taken during normal operations. The system's primary operating parameters were varied: (1) steam flow rate in the stripping tower; (2) pressure in the stripping tower; (3) groundwater flow rate in th stripping tower; and (4) the regeneration frequency of the GAC beds. An Application Analysis describing EPA's test results will be available in April, 1991. The technology may be applicable to your site.

For more information, call Gordon Evans at EPA's Risk Reduction Engineeri at FTS-684-7684 or 513-569-7684.

The ATTIC at Oak Ridge

by Cheryl Campbell, Alternative Treatment Technology Center

Some of the Department of Energy (DOE) operations at Oak Ridge, Tennessee have soil extensively contaminated with polychlorinated biphenyls (PCBs). Phil McGinnis, a Program Manager at the Oak Ridge National Laboratory (ORNL), was working on a proposal to demonstrate bioremediation for site cleanup. Phil contacted Andrea Richmond, an Information Specialist at the University of Tennessee, who consults for ORNL, about innovative technologies for the treatment of PCB-contaminated soil by aerobic and anaerobic microorganisms. In her own search, bioremediation technologies for PCB contaminated soil had been rather scarce; so, Andrea contacted the ATTIC system operator who conducted a search for bioremediation of PCB contaminated soil. Andrea had used the ATTIC system previously and had found it to be very useful. This new search proved fruitful, too. The most useful information concerned sites at which the technology had been demonstrated, names of vendors who had conducted bioremediation and data on the cost of bioremediation vs. incineration. The ORNL staff had narrowed their search to bioremediation and incineration and they were seeking specific comparative data on these technologies. They realized there were differences between these technologies which included costs of treatment, treatment times and demonstrated clean up levels. Using information found in ATTIC, the ORNL staff was able to later estimate that the cost of *in situ* biological treatment would be approximately $50 to $100 per ton. The usual way of treating PCBs in soil is by excavation and incineration of the contaminated soil at a much higher cost. Some ATTIC case study abstracts involved field demonstrations of biological treatment of PCB contaminated sludges and soils. Mr. McGinnis used the information, which contributed to his proposal being funded.

When this search for Oak Ridge was conducted (November 16, 1990) more than 13% of the ATTIC Database contained information on bioremediation activities. Since that time, the system has grown to include more information on bioremediation. Currently, 20% of the database contains this type of information.

For help on how to use ATTIC, as well as information, call the ATTIC operator at 301-816-9153. Cheryl Campbell and her staff are ready to assist you. Or, you can also call Myles E. Morse, EPA Program Manager for ATTIC, at FTS-475-7161 or 202-475-7161.

Less Energy & Lower Cost with Army's Low Temperature Thermal Stripping Process

by Cpt. Craig A. Myler, U.S. Army Toxic and Hazardous Materials Agency

VOCs
Low Temperature Thermal Stripping
Soil

Past waste disposal practices at some Army facilities have resulted in soil contaminated with volatile organic compounds (VOCs) from cleaning solvents and fuels. Current methods to treat this soil contamination include incineration, disposal at a landfill or hazardous waste disposal facility and *in situ* volatilization. The Army has devised a fourth way, with a system that expends less energy than an incinerator and is cheaper to run. The process, Low Temperature Thermal Stripping, or LTTS, has been developed and demonstrated by the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), a Field Operating Agency for the U.S. Army Corps of Engineers at the Aberdeen Proving Ground in Maryland. Pilot and field tests during the past few years have proved the success of the LTTS. Currently, the Navy is using it to clean up the Crow's Landing Site in California.

The Army expects that the LTTS process will cut the former incineration costs of $300 per ton of soil by 50%. LTTS also overcomes limitations encountered with lower cost *in situ* volatilization/vacuum extraction. With *in situ* volatilization, the contaminated soil cannot be very wet and not all VOC-contaminated soil is treatable, particularly silty and clayey soils with low permeabilities.

How does the LTTS process work? Contaminated soil is fed through an opening at the top of the system, called the soil feed hopper. The soil falls into the main part of the system, or thermal processor. The thermal processor consists of two separate but identical units, each containing four large, hollow screws, eighteen inches in diameter, twenty feet long. As the screws turn, they churn the soil, breaking it up and pushing it from the feed end of the processor to the discharge end. In the meantime, hot oil is pumped through the inside of the screws. The constant churning of the soil and movement of hot oil up and down the length of the screws heats the soil and volatilizes

(see LTTS, page 4)

New for the Bookshelf

Recent EPA publications are available from ORD's Center for Environmental Research Information (CERI) in Cincinnati. You can order them on the OSWER BBS or directly from CERI's Publications Unit at FTS-684-7562 or 513-569-7562. You must have the EPA document number or the exact title to order a document.

Approaches for Remediation of Uncontrolled Wood Preserving Sites
An overview of the process of remediation of uncontrolled wood preserving sites, emphasizing site specific factors and multiple technology utilization.

Document No. EPA/625/7-90/011

LTTS

(from page 3)

the VOCs. Additional heat is provided by the walls of the processor, called the trough jacket, which also contains flowing hot oil. The thermal processor heats up to a maximum of about 650 degrees Fahrenheit. Once the VOCs are vaporized, they flow through piping into a burner or other means of treatment, such as a scrubber or carbon adsorption system. The VOC-free airstream then passes through a discharge stack monitored for VOCs. In the meantime, the soil—now virtually VOC-free—falls into the discharge end of the processor, where it can be put back into the excavation area.

What have previous demonstrations concluded? The results of the pilot and field tests showed the following for the particular soils and VOCs treated: (1) more than 99% of the VOCs were removed from the soil; (2) the process equipment available is capable of treating at least 10 tons of contaminated soil per hour; and, (3) there was a 99.99% destruction and removal efficiency in the afterburner incineration step. As an example, trichloroethylene was reduced from concentrations greater than 111 parts per billion (ppb) to 5 ppb; and, toluene was reduced from 8300 ppb to less than 2 ppb.

Federal agencies can send site soil samples to the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi, for pre-screening to determine how well the soil types can be treated by LTTS. The work will be performed on a cost-reimbursable basis. The results will be published in a report discussing the results of the soil samples that were used. The WES target date for having the treatability study capability is May 1991. However, some laboratories have the capability to perform this service now (for both Federal agencies and non-Federal parties).

Federal agencies interested in sending soil samples for pre-screening by WES should contact Daniel Averett, WES, at 601-634-3959. For more information on the technical aspects of the LTTS, or for laboratories with current capability to pre-screen soil samples, contact Cpt. Craig Myler, USATHAMA, at 301-671-2054.

Tech Trends welcomes readers' comments, suggestions for future articles and contributions. Address correspondence to: Managing Editor, Tech Trends (OS-110), U.S. Environmental Protection Agency, 401 M Street, S.W., Washington, DC 20460.

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