36 883 PDF

TREATMENT OF HAZARDOUS LANDFILL LEACHATE BY THE ROCHEM DTM MEMBRANE SEPARATION TECHNOLOGY

Douglas W. Grosse
Risk Reduction Engineering Laboratory
U.S. Environmental Protection Agency
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
(513) 569-7844

Kyle Cook
Science Applications International Corporation
10260 Campus Point Drive
San Diego, CA 92126
(619) 546-6117

Introduction

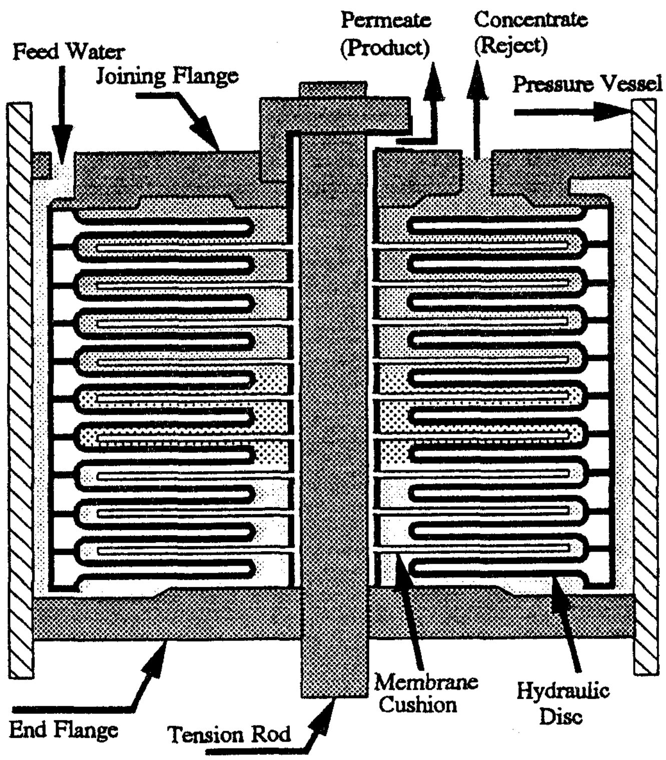
The Disc Tube™ Module (DTM) technology was developed by Rochem Separations Systems, Inc. and designed to remove a variety of organic and inorganic contaminants from liquid hazardous waste streams. The DTM technology is a membrane based technology utilizing an innovative process configuration which allows for treatment of aqueous waste streams such as landfill leachate. Historically, membrane based technologies have been used as a secondary polishing step in treating effluents to meet pretreatment discharge standards. The DTM technology was designed to treat liquids containing higher dissolved solids, turbidity and contaminant levels than previously possible with conventional membrane processes.

The DTM process was evaluated under the Superfund Innovative Technology Evaluation (SITE) program at the Central Landfill in Johnston, Rhode Island during the months of August and September 1994. Approximately 33,000 gallons of hazardous landfill leachate were treated by the DTM technology using reverse osmosis membranes. The leachate contained moderate to high levels of volatile organic contaminants, low levels of heavy metals, and high total dissolved solids. The Developer (Rochem) claimed that the technology was capable of (1) achieving a high percent rejection of the contaminants of concern; (2) recovering ≥75% permeate (treated water); and (3) allowing for a greater resistance to scaling and fouling of membranes than conventional membrane processes.

Technology

The DTM technology is a modular system which utilizes reverse osmosis (RO), ultrafiltration, or microfiltration membrane materials in a modular configuration which offers large feed flow channels for high feed flow velocity, generating a crossflow of feed water over stacked membranes. Purportedly, these system design features allow the DTM greater tolerance for dissolved solids and turbidity; hence, a greater resistance to scaling and fouling of the membranes. Suspended particulates are easily flushed away from the membranes and out of the module during operation.

Figure 1 shows a cutaway of a disc tube module. The modular disc tube is comprised of conventional RO membranes which are formed into octagonal cushions by ultrasonically welding two membranes together at the edges and separated by a layer of porous spacer material on the inside. These cushions are supported by a plastic disc which holds the membrane cushion in place and forms the flow channels for the feed. These membrane cushions are alternately stacked with hydraulic discs on a tension rod. The tension rod houses a conduit for permeate collection from each membrane cushion to facilitate discharge from the module into a product recovery tank. O-rings seal the permeate water channels from the feed water channels. A stack of cushions and discs is housed in a pressure vessel; whereby, flanges seal the ends of the module and provide the feed water input, permeate and reject outlet connections. The number of discs per module, number of modules and the membrane materials can be custom designed to suit the application.



The RO membranes used for this demonstration test are more permeable to water than to organic and/or inorganic impurities. When pressure is applied to a solution (leachate), the aqueous phase (permeate) passes through a semipermeable membrane which, in turn, rejects the contaminants carried by the solution, causing them to be retained in a brine solution (concentrate). These impurities are selectively rejected by the RO membranes. The percentage of water that passes through the membrane is a function of operating pressure, membrane type and concentration of the contaminants.

Methodology

The DTM technology was evaluated for its ability to meet percent rejections established for the target contaminants (VOCs >90%, TOC >92%, TDS >99% and metals 99%) while operating at a treated water recovery rate of 75 percent or greater. In addition, the DTM system was evaluated for treating a hazardous leachate without experiencing an unacceptable level of membrane fouling or scaling, resulting in a loss of membrane flux (flow rate/membrane area).

The Central Landfill site comprises two areas: a 121 acre area and a 33 acre expansion area. The 121 acre area of the site is where disposal of hazardous and non-hazardous wastes took place in the past. Several wells on the site were being used to intercept leachate from a "hot spot" area (0.5 acre) of the site to prevent off-site migration of contaminated liquids. Leachate from one of these wells (MW91ML7) was characterized during a pump test previously conducted. This well was located downgradient from the hot spot area of the landfill; thereby, containing higher concentrations of contaminants than other wells on the site. Leachate produced from this well was deemed to be the most suitable for the DTM field demonstration. Table 1 gives the target constituent profile of the leachate generated from well MW91ML7.

A three-stage DTM system was used for the field demonstration. Two stages were used in series to treat the landfill leachate to produce a final permeate. Both stages utilized standard thin film composite (TFC) RO membranes. The permeate from the first-stage DTM was used as a feed for the second-stage DTM for further removal of contaminants. A third-stage high pressure unit (HPU) was used to further squeeze the concentrate rejected by the first-stage to increase permeate recovery. The permeate from the HPU was directed to the second-stage DTM unit. Each unit was protected by media (sand) and cartridge (10 micron) filters to remove suspended particulates. Acid was also added at the first-stage and HPU for pH control. The system processed approximately 33,000 gallons of hazardous leachate at an average feed rate of 5 gpm. The system operated long enough to allow for several cycles of membrane cleaning (up to 8 hours a day, for 19 days).

Baseline testing was performed prior to and immediately following the Rochem Demonstration test to determine if there had been a loss of membrane flux due to fouling and scaling. Baseline testing procedures, as specified in the QAPP, were modified to account for varying conditions (pressure, flow rates, temperatures and brine concentrations) during the field test in accordance with the Standard Practice for Standardizing Reverse Osmosis Performance Data ASTM D 4516-85. This method allows for collected field data to be normalized against a chosen set of standard operating conditions (average). Using this method, the change in membrane flux was determined after the demonstration test was completed. A saline solution of known conductivity was used for baseline testing.

Table 1 - Target Contaminant Profile (MW91ML7)

Constituent	Average Concentration
VOC	(ug/1)
Chlorobenzene	35,000
Ethylbenzene	1,600
Toluene	2,800
Xylenes	2,300
1,2 - Dichlorobenzene	29,000
1,4 - Dichlorobenzene	1,600
Metals	**(mg/l)**
Calcium	140
Magnesium	200
Sodium	560
Barium	1.4
Iron	49
Manganese	22
Potassium	110
Strontium	0.82
Other Analytes	**(mg/l)**
Total Dissolved Solids	4,100
TOC	360
pH	6.8 Units

Results

During the field demonstration, both laboratory and field samples were collected for analyses. Field measurements included: pressure, temperature, flow, pH, turbidity, and conductivity of the process liquids. A portable organic vapor detector monitored for fugitive emissions during field operation. Laboratory samples were collected from: (1) the raw feed; (2) first-stage feed, reject and permeate; (3) second-stage reject and final permeate; and HPU feed, reject, and permeate. The target contaminants were analyzed along with TOC, TDS, total solids, MBAs and ammonia (see Table 1).

Based upon results obtained from preliminary data reduction, the Developers claim for percent rejection of the target contaminants appears to be met; especially, when considering established standard deviations (SD). Rejection of heavy metals and total dissolved solids was excellent by significantly surpassing the claim for >99% rejection. Similarly, percent rejection of TOC (>96.3) far exceeded the claim of >92%. For target VOCs the Developer's claim of >90% rejection was overall exceeded with 95% rejection of 1, 2-Dichlorobenzene (one of the primary contaminants of concern), and >95% for toluene, xylenes and ethylbenzene. Although, chlorobenzene only achieved 87% and 1, 4-Dichlorobenzene >87.6% rejection, 95% confidence intervals were calculated to be ±3.7% and ±4.1%, respectively.

The second of the three critical claims established for this demonstration pertained to the achievement and maintenance of a treated water recovery rate of 75% or greater. Recovery rates were calculated for each day of operation. There were a total of three (3) days of downtime attributed to system maintenance, resulting in 18 days of actual field data collection. The system water recovery rates ranged from, approximately, 65% to as high as 86%. Overall, the average recovery rate of 73.3% was achieved for the demonstration with a 95% confidence interval of ±2.6%.

The third critical objective of the demonstration test was to determine the extent, if any, of membrane scaling and fouling as measured by the difference in membrane flux before and after system field operation. It was considered an indication of membrane scaling and fouling if a loss of greater than 10% flux was obtained. Baseline procedures were employed for both the first-stage unit and the HPU, separately. One set of actual operating data (average operating conditions) was selected as the standard for each unit. At this time, not all of the data have been completely reviewed. In discussions with the Developer, preliminary results are in question (>10%$_\Delta$) due to the premise that the membranes were not adequately broken in. Manufacturers typically recommended 50-100 hours of continual running before the baseline can be determined for a given membrane on sea water systems. For leachate, Rochem has recently discovered that the same "break-in" period can be 200 hours and more before a baseline determination can be adequately made.

Conclusions

Preliminary results of the SITE demonstration of the DTM system shows that significant percent removal of target contaminants was achieved, exceeding the Developer's claim in most cases. The DTM technology can effectively treat hazardous landfill leachate to the extent that the treated water (permeate) can meet effluent discharge standards (the Rhode Island DEM discharge limits).

The DTM process was also capable of approximating (on the average) the claim of 75% or greater for water recovery efficiency. During peak days of operation as high as 86% was achieved.

Key findings of this SITE demonstration including analytical results will be discussed in detail with the submittal of the Technology Capsule, Innovative Technology Evaluation Report and a videotape.