United States
Environmental Protection
Agency

Municipal Environmental Research
Laboratory
Cincinnati OH 45268

Research and Development

EPA-600/S2-81-179 Oct. 1981

EPA

Project Summary

Production Engineering and Marketing Analysis of the Rotating Disk Evaporator

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Recent EPA-funded research into the on-site, mechanical evaporation of wastewater from single family homes revealed that a rotating disk evaporator (RDE) could function in a nondischarging mode. Such a device has potential use where site limitations preclude conventional methods for on-site disposal.

This study documents a marketing analysis made of the RDE. The marketing analysis defined the market potential for RDE systems, developed a practical design, estimated production and installation costs, and refined market estimates based on cost comparisons.

A small unit suitable for only the most favorable climates would have an FOB factory selling price of about $10,000 if fabricated with aluminum disks. Distribution costs and freight will amount to about $3,300. An additional $8,000 is required for installation (including a large storage tank for periods when freezing prevents evaporation), resulting in a total capital cost of about $22,000. Including amortized capital costs and O&M costs, an RDE system would treat household wastewater for about 3.4 cents/gallon.

Because of these high costs, the potential RDE market is quite small. It is limited to very expensive homes, second homes with no winter occupancy, and high-cash-flow—low-sewage-flow commercial establishments. Furthermore, unfavorable climatic conditions eliminate much of the nation from consideration. In summary, it is unlikely that manufacturers of RDE systems would collectively generate national sales of 100 units/year.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

A number of U.S. Environmental Protection Agency research projects have addressed alternative on-site wastewater treatment systems. In 1978, the University of Colorado completed a project concerned with disposal of septic tank effluent by evapotranspiration and by mechanically assisted evaporation.

The University of Colorado research project indicated that a RDE could function as an on-site disposal method for many areas of the nation where site restrictions preclude the use of other disposal techniques. Furthermore, preliminary cost data suggested the system might be competitive with other on-site disposal alternatives.

To assist in determining if a full-scale demonstration of the RDE device was appropriate, the EPA retained Environmental Resources Management, Inc., to review the University of Colorado results, define the market for such sys-

tems, estimate capital and operating costs for potential system designs, and compare the market potential with other on-site systems.

Rotating Disk Evaporator (RDE) Unit

A schematic diagram of a typical RDE installation is shown in Figure 1. The RDE unit features a row of parallel disks mounted perpendicularly to a rotating horizontal shaft. The disks are partially submerged in a basin containing septic tank effluent. As the disks rotate in the vertical plane, the effluent adheres to the disks and evaporates to the atmosphere.

The main advantage of evaporation is that it provides for complete disposal of sewage without discharge to ground or surface waters. This allows the use of a site otherwise limited by such conditions as highly impermeable soils or steeply sloping topography.

The RDE unit substantially increases the effective evaporation surface for a small rainfall catchment area. Therefore, the RDE unit can function as a nondischarging system in regions characterized by other than arid and semi-arid climates, e.g., areas with high evaporation potential, but with significant precipitation.

When ambient temperature drops below 40°F, water on the disks may begin to freeze. Therefore during low temperature periods, wastewater inflow must be held in storage.

RDE Unit Design

The University of Colorado research determined the optimal operating characteristics for disk submergence, rotational speed, disk spacing, and disk color. Possible materials for the construction of disks are limited to two basic classes—metals and plastics. On the basis of disk material costs alone, aluminum is six to eight times more expensive than plastic. Nevertheless, the use of plastic complicates the anchoring of disks to the drive shaft; turning moment about the shaft tends to soften openings and creep and outright failure could occur.

Recognizing that design flow has a substantial impact on RDE costs and that RDE systems would likely incorporate flow conservation measures in the household, it was decided to use a design flow of 225 gallons/day (850 L/day). This design flow represents a compromise between average flow based on field measurements and flow rates used by regulatory agencies for design purposes.

Pan evaporation rates and temperature data were used to size RDE units for a number of locations in the United States. The 18-inch-diameter size selected by the University of Colorado was used. Results are shown in Table 1.

Estimate of Potential Market

Both temperature and evaportion rate affect the applicability of the RDE device. Disk area varies inversely with evaporation rate. Design storage requirements are based on the number of days the temperature drops below 40°F.

An initial estimate of areas where climatic conditions could support the use of RDE was based on the following criteria: (1) pan evaporation ≥40 inches/year, and (2) no more than 50 days with mean daily temperature on an annual smooth course less than 32°F. Application of these criteria indicated that the states listed in Table 2 would be suitable for RDE units.

Data on new and second home construction were evaluated in conjunction with estimates of sewer and land availability to determine the market potential for mechanical systems. The potential market for these systems is shown in Tables 3 and 4. These tables do not include the potential market for commercial applications; however, the magnitude of the commercial market appears small in comparison.

The maximum potential market over the next 20 years (developed from Tables 3 and 4) is as follows:

South	25,500 units/year	
West	6,500 units/year	Total 32,000/year

The low estimate of 1 percent of new housing translates to about 8,000 units/year. This range of 8,000 to 32,000 units/year represents the

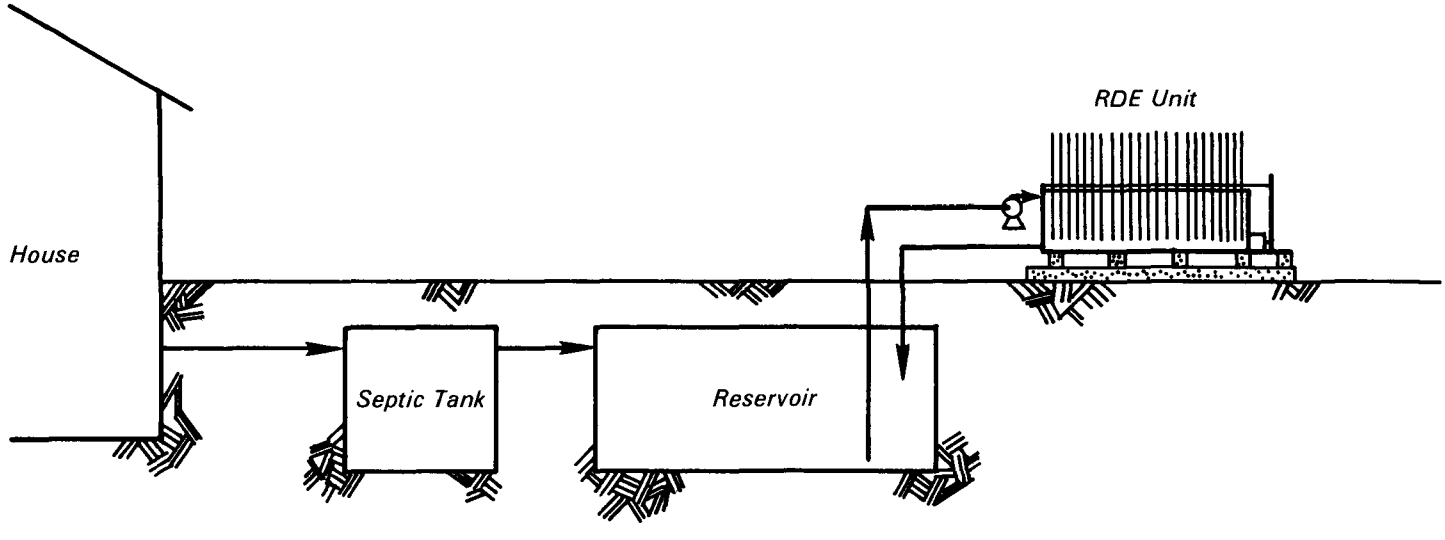

Figure 1. Typical installation of RDE system.

Table 1. *RDE - Storage System Design Sizes*

Location	Maximum Average RDE Evaporation Rate ($L/hr \cdot m^2$)	Number of Disks*	Unit Storage Required (L/m^2)	Storage Required (L)
Billingame, California	0.07	118	160	81,000
Holland, Virginia	0.07	118	140	71,000
Medford, Oregon**	0.05	165	200	140,000
Laven, Texas	0.11	75	200	64,000
Dixon Dam, Kentucky	0.045	183	120	94,000
Wanship Dam, Utah**	0.06	137	200	120,000
Martin Dam, Alabama	0.055	150	81	52,000
Athens, Georgia	0.075	110	120	57,000
Hialeah, Florida	0.090	92	85	34,000
Boulder, Colorado	0.100	82	310	110,000
Canton, New York**	0.045	183	130	110,000
Fairhope, Alabama (1975)	0.055	150	84	54,000
Fairhope, Alabama (1977)	0.065	127	112	61,000

*Based on 850 L/day (225 gal/day) design flow, 4.3 m^2 exposed surface area/disk (78-inch diameter, 28-inch submergence), and exclusive of any safety factor.
**Outside RDE geographic market in Table 2.

Table 2. *States Suitable for RDE*

Arizona	Mississippi
Alabama	New Mexico (50%)
Arkansas	North Carolina
California	Oklahoma
Florida	South Carolina
Georgia	Tennessee
Kentucky (75%)	Texas
Louisiana	Virginia (50%)

potential market for mechanical-based systems.

Within the wastewater treatment business, rarely does a particular manufacturer capture a major portion of the market for any product. Although this is not true for the mechanical-based alternative on-lot systems market, relatively new products in this market have captured only a small share. It is unlikely that a RDE product would make a major penetration. A very strong marketing program would very likely be required to gain as much as 10 percent of the market over the next 20 years.

Based on the above and considering that the market estimates are purposely high, the potential market for RDE units is about 1,000 units/year excluding cost considerations.

Table 3. *Potential Market for Mechanical-Based Systems for New Single Family Housing Within RDE Geographic Market Areas*

	Time Horizon	Primary Residence: Inside SMSA*	Primary Residence: Outside SMSA	Second Home	Total
South	1981-1990	100,000	30,000	60,000	190,000
	1991-2000	100,000	30,000	70,000	200,000
	2001-2010	90,000	30,000	70,000	190,000
	2011-2020	90,000	30,000	50,000	170,000
West	1981-1990	20,000	10,000	20,000	50,000
	1991-2000	20,000	10,000	20,000	60,000
	2001-2010	10,000	10,000	30,000	50,000
	2011-2020	10,000	10,000	20,000	40,000

*Standard Metropolitan Statistical Area

Table 4. *Potential Market for Remedial Retrofits*

Region	Existing Housing	Future Housing
South	5,000/year	1,000/year
West	1,000/year	—

Costs of RDE Systems

Three standard size systems were selected and a production engineering analysis was made for fabricating three design sizes of 80, 110, and 140 disks (78-inch diameter) at annual production levels of 100, 1,000 and 10,000 units. Estimated fabrication costs for 1,000 units/year are presented in Table 5.

If plastic were substituted for aluminum as disk material, costs would be reduced substantially. Polystyrene disks would cost about $6.00 each, representing a $3,400 reduction in material costs for the 80-disk RDE. Elaborate metal spiders are required with plastic disks, however, and these are not included in the cost estimates shown in Table 5. A minimal design featuring plastic disks and five metal spiders conceivably would reduce the price of the 80-disk unit by 50 percent.

Total capital costs for the 80-disk and 140-disk units were estimated as follows:

	80 Disk Unit	140 Disk Unit
RDE (FOB Factory)	$10,200	$16,800
Freight and Distribution	3,300	5,400
Installation	8,100	13,500
Total	$21,600	$35,600

Installation costs include $3,800 for a 10,000-gallon fiberglass reservior. Operation and maintenance costs were estimated at $430/year.

The RDE system is many times more costly than other on-lot disposal alternatives. It is obvious that for any soil system suitable for a discharging system, the RDE device cannot compete on a cost basis.

Based on the cost data developed, the potential market of RDE systems as a nondischarging alternative for unclustered, single family homes was judged to be insignificant. Manufacturers would very likely find it difficult to generate sales of 100 units/year.

The full report, submitted in fulfillment of Contract No. 68-03-2738 by

Table 5. *RDE Estimated Fabrication Costs*

Cost Component	Costs ($)		
	80 Disk RDE	110 Disk RDE	140 Disk RDE
Aluminum disks, 78-in. diameter, 1/16 in. = 0.716 lb/sf @ $1.60/lb = $48.50/disk	$ 3,880	$ 5,335	$ 6,790
Spacers	50	65	87
Shaft, 84 in., 113 in., and 144 in. long @ $0.30/lb	34	46	58
Stub Ends @ $0.26/lb	36	36	36
Intermediate Support @ $0.26/lb	—	17	17
Channel Supports @ $0.30/lb	36	46	56
Steel Plating for Tank @ $0.21/lb	273	328	382
Bearings	523	785	785
Large Gear	39	39	39
Small Gear	18	18	18
Chain	25	25	25
Drive Unit, complete	274	274	274
Paint, Tar, Grit	35	44	52
Subtotal, materials	$ 5,223	$ 7,062	$ 8,619
Labor @ $7/hr	427	553	693
Factory Overhead	854	1,106	1,386
General and Administrative	1,148	1,538	1,888
Profit (25%)	2,551	3,418	4,195
Selling Price, FOB Factory	$10,203	$13,677	$16,781

Environmental Resources Management, Inc., under sponsorship of the U.S. Environmental Protection Agency, was authored by Philip L. Buckingham.

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The complete report, entitled "Production Engineering and Marketing Analysis of the Rotating Disk Evaporator," (Order No. PB 82-101 676; Cost: $8.00, subject to change) will be available only from:

National Technical Information Service
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