United States
Environmental Protection
Agency

Municipal Environmental Research
Laboratory
Cincinnati OH 45268

Research and Development

EPA-600/S2-81-178 Oct. 1981

EPA

Project Summary

Evaluation of On-Site Wastewater Treatment and Disposal Options

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A literature review of published and unpublished data was conducted to identify conceivable on-site systems, including wastewater manipulation, treatment, and disposal options. Wastewater manipulation options included flow reduction, wasteload reduction, and waste segregation. Treatment options included disinfection and biological and physical/chemical methods. Disposal options included air, soil, and surface water methods and practical combinations.

Both tested and untested systems were identified, and combinations of the various components were developed. An equipment inventory was then performed to determine the availability of hardware for the systems, and system components were identified. Data on engineering, economic, and environmental acceptability characteristics were collected.

These systems were evaluated on the basis of performance, operation and maintenance, environmental acceptability, and total annual cost for 15 specific site conditions. Site conditions were defined by soil percolation rate, soil depth, slope, available land area, direct discharge effluent requirements, and net evaporation.

Where site conditions are appropriate (conventional septic tank—soil absorption systems) were found to be the least-cost and top-ranked method of on-site wastewater treatment and disposal. Under other conditions, systems incorporating other methods of disposal, such as soil disposal with modified distribution, mounds, evapotranspiration, irrigation, evaporation, or direct discharge, are appropriate. A septic tank normally provides adequate pretreatment for most of these disposal methods. Where irrigation or surface discharge disposal is used, additional treatment, such as that provided by an intermittent sand filter and iodine disinfection, may be required. Use of low pressure membrane filtration where high quality effluent is required also appears promising, based on very limited operating experience.

This Project Summary was developed by EPA's Municipal Environmental Research Laborabory, 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

The major objectives of a review of the available literature for on-site wastewater treatment and disposal were:

1. To identify potential in-the-house and individual home on-site wastewater treatment, handling, reuse, and disposal options. The on-site unit components included water conservation devices, waterless systems, recycle systems, separation systems, and other wastewater manipulation schemes; biological and physical/

chemical treatment options; and disposal options.

2. To conduct a technological and economic comparative analysis of all manipulation, treatment, and disposal options so that alternatives could be ranked and a small number of selected, most feasible alternatives could be identified.

The data base for the project included both published and unpublished literature and personal interviews. After pertinent data were extracted from the published literature, individual researchers, sanitarians, and consultants were contacted to supply lacking or incomplete unpublished data. Equipment manufacturers were also contacted to obtain nonproprietary data and to discuss relevant specific topics. Data collection and subsequent system evaluations focused on the following topical areas: (1) performance, (2) operation and maintenance requirements, (3) environmental acceptability, and (4) cost.

Wastewater Character and Manipulation

Data on wastewater quantity and quality characteristics, reported by several investigators, consisted of wastewater flow from various household sources, combined household wastewater characteristics, wastewater constituent contributions from various sources, and a summary of blackwater, greywater, and garbage disposal characteristics. The data indicated that on-site systems must be able to accommodate considerable fluctuations in pollutant and hydraulic loadings.

A summary of generic types of flow reduction devices was compiled for both greywater and blackwater sources. Flow reductions of 10% and 40% should be consistently achievable using flow reduction devices for batch flow sources (i.e., toilet, laundry, and dishwasher). Limited information was presented on cost and operation characteristics of gas and oil-fired and electric incinerating, and recirculating and composting toilets. Matrices were developed of 18 potential waste segregation options and potential impacts. In general, segregation options were indicated to have limited applicability.

Wastewater Treatment

Biological systems for which on-site hardware and performance information was available included suspended growth extended aeration units, fixed growth rotating disks, and fixed growth packed reactors. The use of nondischarging lagoons for disposal, such as infiltration/evaporation lagoons, was assessed. Physical/chemical treatment systems reviewed included pressure filtration, gravity filtration, ultrafiltration, and chemical addition and sorption processes. Disinfection options reviewed were for use of chlorine, iodine, ozone, and ultraviolet irradiation.

In all cases, information on system performance, operation and maintenance requirements, environmental acceptability, and costs was summarized. Component comparisons were made for systems with available on-site hardware.

Disposal Options

Soil disposal in the form of a conventional soil absorption field is the most common and accepted on-site disposal method. Site-specific limitations, however, often make other methods of disposal necessary or desirable. Disposal options and their applicability to on-site systems are summarized in Table 1. The options with available on-site hardware and performance data are discussed in the full report.

Comparative Analysis

Technical ranking criteria were developed for a comparative analysis of on-site treatment and disposal systems for a variety of site conditions. The ranking criteria considered system performance, operation and maintenance requirements, scheduled maintenance frequency, reported equipment failure, hardware complexity, and environmental acceptability. The systems were evaluated in three separate categories: (1) systems with available hardware and on-site performance data, (2) systems with available hardware but incomplete (if any) on-site performance data and (3) systems without existing hardware for on-site application that require development.

For systems with available hardware and performance data, the following general conclusions were drawn:

1. A combined septic tank and conventional soil absorption field was the top-ranked and least costly system where site characteristics permit its use.
2. Where shallow soils (0.3 to 1.2 m) would not provide adequate treatment for the combined septic tank, conventional soil absorption field, and mound systems were the top-ranked and least costly systems, if adequate land area is available.
3. Use of combined flow reduction, holding tank, and off-site disposal was the top-ranked and least costly system only where (a) topography prevents "area intensive" construction and direct discharge is not feasible, or (b) where depth to bedrock or groundwater is less than 0.3 m (1 ft) and direct discharge and evapotranspiration (ET) disposal is not feasible. Even with flow reduction, costs were very high.
4. ET disposal (with septic tank pretreatment) was top-ranked and the least costly system where disposal to the soil and direct discharge were not feasible and where evaporation minus precipitation was greater than 5 cm/mo (2 in./month).
5. Disposal by direct discharge was the top-ranked method where (a) soil and ET disposal were not feasible or (b) where limited land area was available for disposal and sufficient flow reduction was not feasible. The top-ranked and least costly treatment for direct discharge was a combined septic tank, covered intermittent or recirculating gravity sand filter, and disinfection system if nutrient discharges were not limited. If nitrogen discharge was limited (<10 mg/L) and a limit of 10 mg/L BOD and SS was required, a combined septic tank, covered intermittent or recirculating gravity sand filter, fixed growth anaerobic reactor, and disinfection system was the top-ranked treatment. If phosphorus was also limited (<2 mg/L), use of the same system with a sand/"red mud" filter substituted for the sand filter and/or elimination of phosphate detergents was the top-ranked treatment system. Nitrogen may also be significantly reduced through the use of a nonwater carriage or recirculating toilet system, but variable household wastewater characteristics make consistent achievement of effluent nitrogen concentrations of <10 mg/L uncertain.
6. Combined septic tank soil absorption with pressure distribution systems were the top-ranked and

Table 1. *Disposal Options*

Generic Type	Performance: Selected Constituents Affected	Performance: Adequacy	O&M Requirements: Frequency of Scheduled Maintenance (#/yr)	O&M Requirements: Hardware Complexity	O&M Requirements: Equipment Failure (requiring unscheduled service)	Environmental Acceptability (potential hazards and nuisances)	Range of Total Annual Cost ($)*
Air							
- evapotranspiration (lined)	BOD, SS, N, P, microbiological	consistent	<1	simple	infrequent	—	300-700+
- lined evaporation lagoon	BOD, SS, N, P, microbiological	potentially consistent	2-4	simple	infrequent	odor and aesthetics	200-350
- mechanical evaporation	BOD, SS, N, P, microbiological	potentially consistent	>4	moderate	unknown	aesthetics	600
- thermal evaporation	BOD, SS, N, P, microbiological	potentially consistent	>4	moderate - complex	unknown	air emissions	1000
Soil							
- soil absorption							
.. "conventional"	SS, BOD, P, N, microbiological	consistent	0	simple	infrequent	groundwater quality impacts	50-150
.. modified distribution	SS, BOD, P, N, microbiological	consistent	≤1	simple	infrequent	groundwater quality impacts	100-250
.. soil modification	SS, BOD, P, N, microbiological	consistent	≤1	simple	infrequent	groundwater quality impacts	200-450
- irrigation							
.. drip	SS, BOD, P, N, microbiological	potentially consistent	2-4	simple	unknown	odors, health effects, asethetics	100-200
.. spray	SS, BOD, P, N, microbiological	consistent	2-4	simple	unknown	odors, health effects, aesthetics	150-250
.. overland flow	SS, BOD, P, N, microbiological	potentially consistent	2-4	simple	unknown	odors, health effects, aesthetics	100-200
Surface Water							
- direct discharge	none	consistent	≤1	simple	infrequent	BOD and SS ≤ 30 mg/l, stream water quality, and effluent toxicity	10-50
Combinations							
- evapotranspiration/ absorption	SS, BOD, P, N, microbiological	consistent	<1	simple	infrequent	groundwater quality impacts	200-350
- unlined lagoons	SS, BOD, P, N, microbiological	consistent	2-4	simple	infrequent	odor, aesthetics and groundwater quality impacts	150-300
- lagoon w/overflow	SS, BOD, P, N, microbiological	consistent	2-4	moderate	infrequent	BOD and SS ≤ 30 mg/l stream water quality, effluent toxicity, odor and groundwater quality impacts	200-350

*Amortized capital cost plus annual operation and maintenance costs. Does not include cost of pretreatment.

least cost systems where soils are excessively permeable.

Additional conclusions reached during evaluation of the top-ranked systems were:

1. Wastewater reuse is a potential method of flow reduction. The cost of treatment for reuse of either combined or segregated waste streams, however, was not typically offset by reduced disposal costs resulting from reduced volume for any of the site conditions considered. Thus, systems incorporating wastewater reuse were not normally economically viable, although they occasionally may be applicable in specific situations (e.g., very limited water availability).
2. Systems incorporating wastewater segregation options were generally not cost-competitive for any of the site conditions considered, unless segregation was a part of flow reduction and flow reduction in excess of approximately 35% of the normal household total was required. Use of a nonwater carriage or recirculating toilet system to control wastewater nitrogen concentrations or segregation of bath and laundry wastewater from kitchen and toilet wastewater to facilitate denitrification, however, may be appropriate if nitrogen discharge limitations are applicable.
3. Systems with available hardware and performance data were available at a reasonable cost for the site conditions considered, except (a) where steep slopes prevent area-intensive construction and direct discharge was not feasible; (b) where soils have very limited purification capacity and direct discharge and evapotranspiration disposal were not feasible; or (c) where available land for disposal was very limited, soil percolation was slow, and direct discharge was not feasible.

The full report, submitted in fulfillment of Contract No. 68-03-2627 by SCS Engineers under sponsorship of the U.S. Environmental Protection Agency, was authored by David H. Bauer, E.T. Conrad, and Donald G. Sherman.

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The complete report, entitled "Evaluation of On-Site Wastewater Treatment and Disposal Options," (Order No. PB 82-101 635; Cost: $18.50, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

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☆ U.S. GOVERNMENT PRINTING OFFICE, 1981 — 559-017/7381

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