United States
Environmental Protection
Agency

Wastewater Technology Fact Sheet

Slow Rate Land Treatment

DESCRIPTION

Slow rate (SR) land treatment is the controlled application of primary or secondary wastewater to a vegetated land surface. It is the oldest and most widely used form of land treatment. The nutrients and the water in partially treated wastewater contribute to the growth of a wide variety of crops, the maintenance of parks, pasture lands, and forests. SR systems can produce a very high quality percolate but also require the largest land area compared to the other land treatment concepts. On a worldwide basis, thousands of systems use wastewater for irrigation in variations of the SR process.

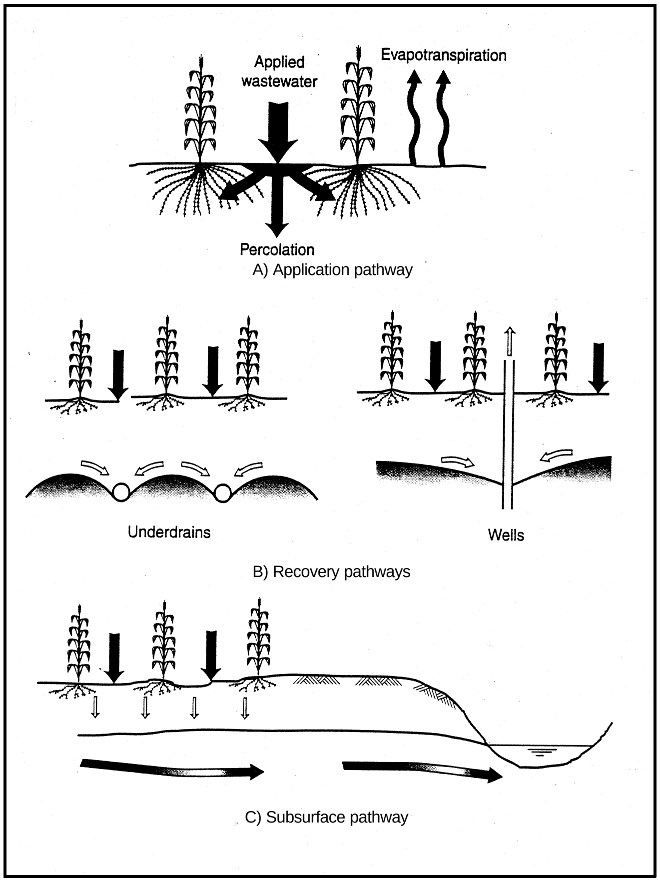
In the SR process, wastewater infiltrates and percolates from the vegetated soil surface and flows through the plant root zone and soil matrix. Water may percolate to the native groundwater or to underdrains or wells for water recovery and reuse of the effluent. Underdrains serve to prevent groundwater mounding under the site, to control groundwater flow, and to minimize movement of leachate onto adjacent property. Figure 1 illustrates the principal hydraulic pathways of water applied in SR systems.

SR systems use standard irrigation methods to distribute the water to agricultural fields, pastures, or forest lands. SR systems can be classified as either slow rate infiltration systems (Type 1) or crop irrigation systems (Type 2). The design objective of slow rate infiltration systems is to maximize wastewater treatment while minimizing land area. Crop irrigation systems are designed to meet crop water needs, which typically requires the use of a larger land area.

APPLICABILITY

The simplicity of land treatment makes it an attractive technology compared with other wastewater technologies.

A large forested sprinkler, slow rate irrigation system, constructed in the early 1980s, in Dalton, Georgia, highlights the applicability of land treatment systems. Dalton is known as the "carpet capital of the world" with 87 percent of its total municipal flow attributed to the carpet industry. The total site contains 3,640 hectares (9,000 acres) with about 1,860 hectares (4,605 acres) of forest being irrigated. The terrain varies from flat to relatively steep (some areas have up to a 40 percent grade) with soil depths of 0.5 to 1.2 m (1.5 to 4 feet). The three secondary treatment plants that feed secondary effluent to the site generate a combined flow of 33 million gallons per day (MGD) (Nutter, 2000).



Source: Crites, et al., 2000.

FIGURE 1 HYDRAULIC PATHWAYS FOR SLOW RATE LAND TREATMENT

The choice of application method depends upon site conditions and wastewater characteristics. In Dalton, lint caused clogging problems in the sprinkler system but improved industrial pretreatment and screening at the pumping stations remediated this problem. In general, advantages of sprinkler application over gravity methods include:

- More uniform distribution of water and greater flexibility in application rates.

- Applicable to most crops.

- Less susceptible to topographic constraints and reduced operator skill and experience.

Gravity methods that utilize shallow flooding of carefully graded fields is generally applicable only for row crops and pastures on relatively flat, uniform terrain.

ADVANTAGES AND DISADVANTAGES

Advantages

SR systems, like other land treatment methods, may be an economical system for wastewater treatment in locations where sufficient land is available at a suitable price. Specific advantages of this technology include:

- Significantly reduced operational, labor, chemical, and energy requirements compared to conventional wastewater treatment systems.

- Economic return from the use and re-use of water and nutrients to provide marketable crops.

- Little or no disposal or effluent production.

- Recycling and reuse of water reduces water distribution and treatment costs for crop irrigation.

Disadvantages

SR systems require a thorough investigation of site suitability before implementation. Land area requirements are significantly greater for SR systems than for conventional wastewater treatment plants and other land treatment methods, such as rapid infiltration and overland flow systems. Slow rate application may not be feasible in most suburban and urban areas. Land requirements include the application area, roads, and winter storage during cold weather if seasonal crops are grown or if frozen soil conditions develop. Temporary storage may also be required for harvesting and maintenance activities.

The removal of pathogens and other pollutants is very effective in SR systems when properly designed and managed. The complex removal mechanisms involved with land treatment processes make site selection a critical part of the design. Specific problems associated with poor site selection include:

- Soil structure dispersion resulting from high dissolved salts concentration.

- Runoff and erosion for sites with steep slopes or lack of adequate erosion protection.

- Inadequate soil or groundwater characterization resulting in operational hydraulic problems.

DESIGN CRITERIA

Proper soils and an adequate land area are paramount criteria when considering SR systems. Table 1 shows the general design parameters for SR systems. The SR process is most suitable for soils of low to medium permeability. Land requirements for this technology are relatively large, but can decrease as the level of influent water quality or degree of pre-treatment increases.

Vegetation serves to reduce nutrient concentrations by uptake, to control erosion, and to maintain or increase infiltration rates.

Considerations for vegetative selection include:

- Suitability of climate and soil conditions.

- Consumptive water use and water tolerance.

TABLE 1 DESIGN CRITERIA

Item	Range
Field Area	56 to 560 acres/MGD
Application Rate	2 to 20 ft/yr (0.5 to 4 in/wk)
BOD Loading	0.2 to 5 lb/acre/d
Soil Depth	at least 2 to 5 ft
Soil Permeability	0.06 to 2.0 in/hr
Lower Temperature Limit	25 deg F
Application Method	sprinkler or surface
Pretreatment Required	preliminary & secondary
Particle Size (for sprinkler applications)	Solids less than 1/3 sprinkler nozzle

Source: Crites, et al., 2000.

- Nutrient uptake and sensitivity to wastewater constituents.
- Economic value and marketability.
- Length of growing season.
- Ease of management.
- Public health regulations.

Design considerations for the sprinkler system include:

- Field conditions (shape, slope, vegetation, soil type).
- Climate.
- Operating conditions.
- Economics.

Design slopes should be less than 15 percent to promote infiltration rather than surface runoff.

References 1, 2, and 6 provide detailed design guidance for SR systems. For planning purposes, a rough estimate of the total land area required for an SR system can be developed using the following equations:

Warm climates and/or 12 month per year operation:

$$A = 190(Q)$$

Cold climates and/or 6 month per year operation:

$$A = 280(Q)$$

Where: A = total site area, acres

Q = design flow, MGD

These equations are valid up to a design flow of about 10 MGD, and include an allowance for a temporary storage pond or access roads. Pretreatment is not included.

PERFORMANCE

Performance of SR systems in reducing BOD, TSS, nitrogen, phosphorus, metals, trace organics, and pathogens is generally very good. Table 2 shows expected removals for typical pollution parameters by SR systems. Nitrogen removal occurs through vegetative uptake, biological reduction through nitrification/denitrification in soil, and ammonia volatilization.

Limitations

Land treatment of wastewaters by the SR process is limited by several factors, including climate, the slope of the land, and soil conditions. Wastewater application may need to be reduced during wet weather periods, creating a need for an adequate storage volume during such periods. In cold climates, frozen soil conditions may also slow application during the winter months. Other

TABLE 2 EFFLUENT QUALITY

Parameter	Percent Removal
BOD	90 to 99+ percent
TSS	90 to 99+ percent
TN	50 to 90 percent
TP	80 to 99 percent
Fecal Coliform	99.99+ percent

Source: Crites, et al., 2000.

disadvantages include high land requirements and potential odor and vector problems if adequate pretreatment is not employed. Other limitations of the SR process include:

- Crop water tolerances.
- Nutrient requirements.
- Sprinkling limitations (wind conditions, clogging of nozzles).
- May need pretreatment for solids, oil, and grease.

OPERATION AND MAINTENANCE

Proper operation and maintenance (O&M) is required for SR land treatment systems to perform as intended. In general, labor requirements for land treatment systems will be less than those for conventional wastewater systems. When crop harvesting is required, there will be a greater requirement for labor. Monitoring requirements can include applied wastewater, groundwater, soil, and vegetation. Vegetation grown on SR systems is usually harvested on a routine basis. Dikes and berms for ponds require regular investigation to check for burrowing animals or decay/destruction of the structure and liner material. Systems that use sprinklers should have a regular inspection and cleaning schedule, including regular draining of lines and pipes in seasonal operation to avoid corrosion. Pumps, valves, and other mechanical elements require routine maintenance, including lubrication.

COSTS

Capital costs for land treatment systems include (Crites, Reed, and Bastian, 2000):

- Transmission.
- Pumping.
- Preapplication treatment.
- Storage.
- Field preparation.
- Distribution.
- Recovery.
- Land.

There will be operation and maintenance costs with all of these areas except land purchase and preparation. Other O&M costs may include monitoring, site and crop management, and harvesting. Other costs may include buildings, roads, relocation of residents, and purchase of water rights.

A preliminary estimate of costs for planning purposes can be obtained using the following equations.

Slow Rate, Sprinklers, Underdrained

Construction costs ($)	O & M Costs ($/yr)
$C = (3.187)(Q)^{0.9331}$	$C = (0.1120(Q)^{0.8176}$

Slow Rate, Sprinklers, Not Underdrained

Construction Costs ($)	O & M Costs ($/yr)
$C = (1.71)(Q)^{0.999}$	$C = (0.205)(Q)^{0.5228}$

Where: C = costs in millions of dollars
Q = design flow, MGD

These costs are valid up to about a flow of 10 MGD. Increase construction costs by about 5 percent for solid-set sprinklers; decrease construction costs by about 5 percent for center pivot sprinklers. Increase O & M by 5 percent for center pivot sprinklers; decrease by 5 percent for solid-set. Underdrain costs assume a six foot deep pipe network. A 75-day storage pond is included in these cost estimates, but pretreatment and land costs are not.

REFERENCES

Other Related Fact Sheets

Rapid Infiltration Land Treatment
EPA-832-F-02-018
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Other EPA Fact Sheets can be found at the following web address:
http://www.epa.gov/owm/mtb/mtbfact/htm

1. Crites, R. W. and G. Tchobanoglous, 1998. *Small and Decentralized Wastewater Management Systems.* McGraw Hill.

2. Crites, R. W., S. C. Reed, and R. K. Bastian, 2000. *Land Treatment Systems for Municipal and Industrial Wastes*. McGraw Hill.

3. Metcalf and Eddy, 1991. *Wastewater Engineering: Treatment, Disposal, Reuse.* McGraw Hill.

4. Nutter, W., 2000. Personal communication with Parsons, Inc.

5. U. S. EPA, 1980. *Innovative and Alternative Technology Assessment Manual.* U. S. EPA MERL, Cincinnati, Ohio.

6. U. S. EPA, 1981. *Process Design Manual: Land Treatment of Municipal Wastewater.* U. S. EPA CERI, Cincinnati, Ohio.

7. U. S. EPA, 1984. *Process Design Manual: Land Treatment of Municipal Wastewater, Supplement on Rapid Infiltration and Overland Flow.* U. S. EPA CERI, Cincinnati, Ohio.

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