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Project Summary

Overland Flow Treatment of Domestic Wastewater in Northern Climates

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A pilot overland flow wastewater treatment system at Laramie, Wyoming, was tested to determine the ability of overland flow to treat municipal wastewater in a location having long, cold, and dry winters. The wastewater distribution system functioned well even during the coldest weather. The pilot system treated raw wastewater adequately during the six warmer months of the year; however, during the six colder months, treatment was inadequate for both raw wastewater and primary effluent when applied on an intermittent schedule.

This Project Summary was developed by EPA's Robert S. Kerr Environmental Research Laboratory, Ada, OK, 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

Overland flow, although a relatively new process for municipal wastewater treatment in the United States, has been shown to be a viable wastewater treatment system in warm climates; however, its effectiveness during the winter in the colder regions of the United States is still open to question. This study was developed to evaluate the ability of overland flow treatment systems to treat municipal wastewater in a cold, dry northern climate using cyclic dosing for eight hours a day, five days a week.

Overland flow plots were constructed adjacent to the City of Laramie, Wyoming, wastewater lagoons. The construction phase of the project began in September 1980 and operation of the system began in August 1981. The system operated on a regular schedule from August 1981 through July 1983.

Seven plots were constructed with the dimensions, slopes, and application rates shown in Table 1. Raw municipal wastewater was applied directly to two plots while the other five plots were treated with primary effluent fed from a settling pond having three days' detention time. Application was by gated pipe with flow rates controlled by the gate settings.

During the fall of 1980, the plots were laid out and graded. Final grading and planting occurred the following spring. Two of the primary plots were seeded on June 12, 1981 with forages of various species ('Garrison' creeping meadow foxtail, reed canary grass, western wheatgrass, timothy, tall fescue, smooth broomgrass, redtop grass, and alsike clover) to determine survival ability. The remaining plots were covered with a transplanted sod consisting mainly of sedges, rushes, and 'Garrison creeping meadow foxtail. The sod was used to represent fully established forage prior to the startup of the overland flow treatment system.

During operation the system applied wastewater eight hours per day, five days per week. Water quality data were collected every two weeks beginning August 1, 1981. The water quality data included samples of the applied raw and primary wastewater and the effluent from each plot, as well as samples from adjacent monitor wells.

System Operation

The wastewater distribution system was designed to operate during Laramie s

Table 1. Parameters for Plots

Plot No.	Type of Influent	Type of Vegetation	Length (m)	Width (m)	Slope (%)	Hydraulic Loading (cm/week)	Application Rate (m^3/m hr)
1	Raw	Sodded	59.8	9.2	1.3	15	0.22
2	Raw	Sodded	60.1	8.2	1.3	10	0.15
3	Primary	Sodded	61.6	6.4	1.6	30	0.46
4	Primary	Sodded	62.2	6.7	1.6	20	0.31
5	Primary	Sodded	61.9	6.7	1.6	15	0.23
6A	Primary*	Seeded	61.9	6.7	1.5	20	0.31
6B	Primary*	Seeded	60.7	6.7	1.5	20	0.30

Plots 6A and 6B were taken as a single plot.

coldest weather. The system operated and applied wastewater without problems in cold weather. The only difficulty was that the low flow rates required for the project dictated that the oversized sliding gates controlling the application rates were manually opened only slightly (01.0cm). This problem was caused by solid particles in the raw wastewater plugging the gated pipe openings controlling wastewater delivery to plots 1 and 2. The gates applying influent to the primary wastewater plots did not encounter a plugging problem. On these latter plots, the gates could be left for several days before a scum formed requiring cleaning. The plugging problem on the raw plots caused the system to be labor intensive.

To relieve the plugging problem, the size of the sliding gate openings was increased to allow passage of solids to the raw plots. To maintain the desired application rates, fewer gates were operated, causing a decrease in the uniformity of application.

Surge flow was also tested as a method for increasing flow rates while water was applied at the same volume. In the surge flow method, water is applied in an intermittent or pulsating fashion according to a specified cycle of on and off times. The sewage flow test indicates that this application method is a feasible solution to plugging problems in an overland flow waste treatment system using a gated pipe. On other full-scale projects, fine screens have successfully controlled plugging problems.

Although the distribution system performed satisfactorily in cold weather, the plots did not function well as treatment systems. Winter operation led to a number of problems with the ice pack accumulation and therefore reduced waste water treatment efficiency. Ice pack formation began near the lower ends of the plots. Once the ice packs began forming, they continued to develop as flowing water froze on the top of the plots. When applied wastewater flowed beneath the ice packs, some treatment did occur in the soil media; however, a uniform flow of wastewater could not be consistently maintained. The water which did flow under the ice packs generally channeled its way through the packs instead of spreading out uniformly over the soil. Also, the ice pack seldom completely covered the entire surface of the plots but rather only the lower portions of the plots. In general, the lack of uniform sheet flow and the tendency for channeling to occur seriously affected treatment.

Development and change of the vegetative cover on the seeded plots occurred throughout the duration of this project. Of the eight seeded species, only the 'Garrison' creeping meadow foxtail and western wheatgrass survived the first winter. During the first year of operation, however, the degree of vegetative coverage on the seeded plots was much less than that on the sodded plots. A dramatic change in vegetation composition occurred during the second year of operation. The 'Garrison' creeping meadow foxtail was the dominate species at the end of the second winter (the beginning of the third growing season) on both the seeded and sodded plots. The sedges and rushes originally in the sodded plots did not compete well with the 'Garrison' creeping meadow foxtail which increasingly dominated the seeded plots in the second and third years. Yield samples taken during the third growing season (the summer of 1983) indicate that the vegetative cover on the seeded plots had increased to a point similar to the cover on the sodded plots (Table 2).

System Performance

During the summer months (May through October) the system provided acceptable treatment; however, treatment effectiveness decreased during the winter months (November through April). Average summer and winter influent and effluent concentrations are shown in Table 3 for NO_3-N, NH_3, TKN, BOD, TSS, and Total Phosphates. The low winter treatment levels may be partially attributed to the low air temperatures during this period and partially to the channeling of water within the ice pack. Further, the total precipitation from November 1981 through April 1982 was only 5.61 cm while from November 1982 through April 1983 it was 20.12 cm. These values indicate very little opportunity for a snow cover to develop on the plots and to provide an insulating layer for the soil prior to the freezing of the soil. Generally, because the flow tended to occur on top of the ice pack, there was seldom any snow accumulation on the plots.

Comparison of treatment on the seeded and the sodded plots showed treatment on the seeded plots to be inferior until the middle of the summer of 1982. During the last year of the study, there were no consistent treatment differences between seeded and sodded plots. Not until the middle of the summer of 1982 did the vegetation on the seeded plots develop a crop canopy thick enough to nearly cover the soil. Generally then, in a northern climate, up to a year will be required to establish adequate vegetation on seeded plots to achieve treatment similar to that obtained from established plots.

Measurements were taken to determine the water balances for the plots. The water balances were determined by measuring the application rate and effluent flow rate from the plots and by calculating the evapotranspiration losses using the SCS Blaney-Criddle formula as calibrated for the Laramie area for mountain meadow vegetation. Infiltration was then calculated as the difference between water applied and the sum of the effluent volume plus evapotranspiration. The water recovery for the plots with the higher application rates (20 and 30 cm/wk) ranged from 27 to 52 percent

Table 2. Forage Yields from Test Plots for 1983

Plot No.*	Seasonal Yield (t/ha)
1	8.69
2	10.97
3	8.27
4	8.58
5	9.74
6A	7.56
6B	10.20

Plots 1 through 5 sodded; plots 6A and 6B seeded.

Table 3. Comparison of Treatment During Summer and Winter (mg/l)

Parameter	Period	Influent		Effluent					
		Raw	Primary	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
NH_3	Summer*	21.5	15.3	9.4	7.6	7.7	7.1	4.5	10.3
	Winter	23.1	21.2	18.2	17.9	19.5	19.4	17.6	20.4
TKN	Summer	28.9	22.3	12.3	12.8	12.2	11.1	9.3	15.8
	Winter	32.7	26.3	23.4	23.1	23.7	23.3	21.9	24.9
NO_3	Summer	2.4	2.2	4.5	3.1	3.7	3.3	2.7	2.7
	Winter	3.4	2.0	5.8	4.7	4.9	4.9	8.5	2.5
BOD_5	Summer	125.7	101.3	25.6	26.7	38.4	37.0	33.4	48.2
	Winter	145.2	109.3	67.2	69.9	81.6	81.4	78.6	85.0
TSS	Summer	46.6	22.8	50.1	57.4	14.8	12.5	49.0	19.3
	Winter	61.3	18.4	30.9	28.6	17.9	25.6	38.2	31.7
T-P	Summer	17.5	16.8	12.3	13.2	13.6	12.2	11.0	13.3
	Winter	18.0	17.7	16.2	16.8	17.2	16.5	16.7	17.2

*Summer = May through October.
Winter = November through April.

with an average recovery of 39 percent. Infiltration accounted for approximately 50 percent of the applied water. Infiltration rates after establishment of vegetation were nearly twice that measured before establishment of vegetation. Water quality data from adjacent monitor wells showed a significant increase in nitrogen content over the life of the study. On future projects with soils of this type, it will be necessary to reduce infiltration by compaction or other means to protect the groundwater.

Conclusions

The results of this project show that a wastewater distribution system for overland flow treatment can be made to operate in a severe northern climate such as exists at Laramie. The distribution system applied wastewater virtually without any problems for two years except for plugging of the gated pipe used for delivery of wastewater on the raw plots.

Vegetation, mainly 'Garrison' creeping meadow foxtail, survived when planted from seed and was nearly fully established during the second growing season. It did require about a year for the seeded plots to provide treatment equivalent to plots with fully established vegetation.

The overland flow treatment system provided good treatment during the six summer months but was less effective during the winter months. Much of the reason for the lack of treatment during the winter months at Laramie appears to be due to the low amounts of snowfall received prior to the soil freezing. The plots were generally bare except for the ice packs which developed on the lower portions of the plots due to the freezing of the wastewater. The design and operating condition of the study resulted in a comparative low level of treatment in the winter months.

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***Lowell E. Leach** is the EPA Project Officer (see below).*
The complete report, entitled "Overland Flow Treatment of Domestic Wastewater in Northern Climates," (Order No. PB 85-115 806; Cost: $14.50, subject to change) will be available only from:
National Technical Information Service
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Springfield, VA 22161
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