# USING LIVESTOCK WASTEWATER WITH SDI
## A STATUS REPORT AFTER THREE SEASONS

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## ABSTRACT

Using subsurface drip irrigation (SDI) with lagoon wastewater has many potential advantages. The challenge is to design and manage the SDI system to prevent emitter clogging. A study was initiated in 1998 to test the performance of five types of driplines (with emitter flow rates of 0.15, 0.24, 0.40, 0.60, and 0.92 gal/hr-emitter) with lagoon wastewater. A disk filter (200 mesh, with openings of 0.003 inches) was used and shock treatments of chlorine and acid were injected periodically. Over the course of three seasons (1998-2000) a total of approximately 52 inches of irrigation water has been applied through the SDI system. The flow rates of the two smallest emitter sizes, 0.15 gal/hr-emitter and 0.24 gal/hr-emitter have decreased approximately 30% during the three seasons, indicating some emitter clogging. The three largest driplines (0.40, 0.60, and 0.92 gal/hr-emitters) have had less than 5% reduction in flow rate. The disk filter and automatic backflush controller have performed adequately with the beef livestock wastewater in all three years. Based on these results, the use of SDI with beef lagoon wastewater shows promise. However, the smaller emitter sizes normally used with groundwater sources in western Kansas may be risky for use with lagoon wastewater and the long-term (> 3 growing seasons) effects are untested.

## INTRODUCTION

In response to increasing nationwide concern about problems associated with livestock wastewater generated by confined animal feeding operations, K-State Research and Extension initiated a project to address odor, seepage into groundwater and runoff into surface water supplies. Subsurface drip irrigation (SDI) is a potential tool that can alleviate all three problems, while still utilizing livestock wastewater as a valuable resource for crop production. A study was begun in 1998 on a commercial beef feedlot to answer the engineering question, ***"Can SDI be successfully used to apply livestock wastewater?"***

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Approximately 8 million cattle are on feed in the central and southern Great Plains of the USA; more than 2 million are in Kansas alone. Using the Kansas design parameter of 250 $ft^2$ per animal, the land area of feedlots in the Great Plains is approximately 45,500 ac, and that in Kansas is approximately 11,400 ac. Perhaps 20 to 33% of average annual precipitation in the Great Plains could be collected as runoff from feedlots. Assuming 20% runoff and an average annual precipitation of 20 inches, approximately 3,700 and 15,000 ac-ft of runoff from feedlots might be available annually in Kansas and the Great Plains, respectively. This feedlot runoff, minus any evaporation from the lagoons, must be disposed of by land application.

Using subsurface drip irrigation (SDI) with this livestock wastewater has many potential advantages. These include, but are not limited to,

- Saves fresh water for other uses
- Reduces groundwater withdrawals in areas of low recharge
- Rich in nutrients, such as N, P, and K, for crop growth
- Reduced human contact with wastewater
- Less odors and no sprinkler aerial pathogen drift
- No runoff of wastewater into surface waters
- Subsurface placement of phosphorus-rich water reduces hazards of P movement into streams by runoff and soil erosion
- Greater water application uniformity resulting in better control of the water, nutrients, and salts
- Reduced irrigation system corrosion
- Reduced weather-related application constraints (especially high winds and freezing temperatures)
- Increased flexibility in matching field and irrigation system sizes
- Better environmental aesthetics

Worldwide, the leading cause of microirrigation system failure is clogging of the emitters. Therefore, it is easy to recognize that prevention of emitter clogging will be the primary design and management challenge of using SDI with this particle-rich, biologically active wastewater. Given that challenge, the objective of this project was to measure the performance of five different dripline types as affected by irrigation with filtered but untreated water from a beef feedlot runoff lagoon.

## METHODS

This project was conducted at a beef cattle feedlot in Gray County, KS. The soil type is a Richfield silt loam. As is typical for beef feedlots in the region, precipitation runoff water from beef cattle pens was collected in a single-cell lagoon. Selected wastewater characteristics are shown in Table 1.

**Table 1. Selected wastewater characteristics, Midwest Feeders, KS, 1998-2000.**

| Sampling Date | pH | EC mmho/cm | SAR | N ppm | P ppm | K ppm | TDS ppm | BOD ppm | TSS ppm |
|---|---|---|---|---|---|---|---|---|---|
| Mar. 6, 1998 | 8.00 | 2.93 | 1.8 | 118 | 35 | 336 | 1875 | N/S | N/S |
| Jun. 5, 1998 | 7.81 | 2.56 | 1.9 | 92 | 30 | 341 | 1613 | N/S | N/S |
| Jul. 17, 1998 | 7.84 | 2.54 | 2.0 | 67 | 30 | 349 | 1625 | N/S | N/S |
| Jul. 31, 1998 | 7.64 | 2.70 | 2.0 | 89 | 30 | 383 | 1728 | N/S | N/S |
| Aug. 21, 1998 | 7.60 | 2.90 | 2.2 | 51 | 33 | 428 | 1856 | N/S | N/S |
| Sep. 1, 1998 | 7.90 | 3.60 | 2.3 | 84 | 32 | 467 | 2304 | 96 | 190 |
| May 12, 1999 | 8.20 | 5.29 | 2.9 | 260 | 39 | 724 | 3386 | 1033 | 580 |
| Aug. 13, 1999 | 7.60 | 4.30 | 2.9 | 160 | 39 | 672 | 2739 | 405 | 1320 |
| Sep. 10, 1999 | 8.00 | 5.30 | 2.8 | 140 | 31 | 724 | 3379 | 255 | 440 |
| Jun. 23, 2000 | 7.80 | 4.90 | 2.9 | 240 | 53 | 828 | 3136 | 998 | 533 |
| Jul. 13, 2000 | 8.10 | 5.20 | 2.7 | 250 | 53 | 828 | 3328 | 834 | 740 |
| Aug. 25, 2000 | 8.00 | 5.10 | 3.0 | 210 | 31 | 888 | 3290 | 228 | 940 |

N/S: Not sampled.
Abbreviations: N: nitrogen, P: phosphorus, K: potassium,
TDS: total dissolved solids, TSS: total suspended solids,
BOD: biochemical oxygen demand.

In April 1998, driplines were installed 17 inches deep and on a lateral spacing of 60 inches. Each plot was 20 ft wide (4 driplines) and 450 ft long. Plots were arranged in a randomized complete block design with three replications. There was a border plot (using the 0.40 gal/hr-emitter laterals) at each of the north and south ends for a total of 17 plots. The system installation and testing were completed on June 16. The first wastewater was used for irrigation on June 17. After completion and testing of the system, the lagoon wastewater was the only water that has been applied with the SDI system; no fresh clean water has been used for irrigation, flushing, or dripline chemical treatment. Corn was the irrigated crop in all three seasons.

Five drip irrigation lateral line (dripline) types, each with a different emitter flow rate (and thus different emitter size), were tested (Table 2) to determine the optimum emitter size that would be less prone to clogging with the wastewater. Agricultural designs of SDI in the Great Plains with groundwater typically use lower flow rate emitters. The emitter flow rates and flow path dimensions were obtained from the manufacturers.

**Table 2. Selected emitter characteristics for the driplines used in the SDI study using livestock wastewater, Midwest Feeders, KS, 1998-2000.**

| Emitter flow rate, (gal/hr) | Flow path dimensions, width by height by length (inch) | Flow path area, ($inch^2$) | Operating inlet pressure (psi) |
|---|---|---|---|
| 0.15 | * | * | 8 |
| 0.24 | 0.0212 by 0.0297 by * | 0.000663 ** | 8 |
| 0.40 | 0.028 by 0.032 by 0.787 | 0.000896 | 10 |
| 0.60 | 0.034 by 0.037 by 0.713 | 0.001258 | 10 |
| 0.92 | 0.052 by 0.052 by 0.610 | 0.002704 | *** |

* These dimensions were not available from the manufacturer.

** Flow path was not rectangular, so the area differs from the product of the width X height.

*** This product was a pressure-compensating emitter. Inlet pressure was greater than 30 psi.

The wastewater was filtered with a plastic grooved-disk filter with flow capacity about 25% greater than the filter manufacturer's recommendations for wastewater (1168 $in^2$ for our maximum flow rate of 120 gal/min). The disks were selected to provide 200-mesh equivalent (openings of 0.003 inches) filtration even though the manufacturers' recommendations for all driplines were filtration of 140 mesh or finer. A controller was used to automatically backflush the filter after every hour of operation or when the differential pressure across the filter reached 7 psi. To help keep bacteria and algae from growing and accumulating in the driplines and to clean lines of existing organic materials, acid and chlorine occasionally were injected simultaneously into the flow stream at injection points about 3 ft apart. Acid was added at a rate to reduce the pH to approximately 6.3. The acid used was N-pHuric 15/49, and the chlorine source was commercial chlorine bleach (2.5% Cl). Flushing (10 dripline volumes) to clean the lines and injections took place on the schedule shown in Table 3.

Generally, daily irrigations of 0.25 to 0.40 inch were made each season from June to early September, except when crop water use did not exceed precipitation or when the irrigation pump was inoperable. Each plot received the same daily application amount, so plot run times varied according to dripline flow rate. Seasonal applications were 21, 15, and 16 inches in 1998, 1999 and 2000, respectfully. The 1998 amount greatly exceeded the crop water requirements but allowed more rigorous testing of the system. Additional flow tests were conducted between growing seasons (Oct. 6-7 and Nov. 17, 1998 and Nov. 3, 2000). In Kansas, few crops require irrigation during the winter months, so the system was allowed to remain idle during the overwinter periods. This stagnation period might increase the potential for system degradation from clogging, but it represents practical operating conditions for this climate.

**Table 3. Dates of flushing and injection, Midwest Feeders, KS, 1998-2000.**

| Date | Flush ? | Injection ? |
|---|---|---|
| July 9, 1998 | | Y |
| July 27, 1998 | | Y |
| August 4, 1998 | Y | Y |
| August 31, 1998 | | Y |
| September 2, 1998 | Y | Y |
| September 4, 1998 | | Y |
| October 6, 1998 | Y | Y |
| November 17, 1998 | Y | Y |
| June 8, 1999 | Y | Y |
| June 9, 1999 | Y | |
| July 28, 1999 | | Y |
| August 5, 1999 | Y | Y |
| August 6, 1999 | Y | |
| August 24, 1999 | Y | Y |
| August 25, 1999 | Y | |
| September 10, 1999 | | Y |
| April 28, 2000 | Y | |
| May 3, 2000 | | Y |
| June 13, 2000 | | Y |
| June 21, 2000 | | Y |
| June 23, 2000 | Y | |
| August 1, 2000 | | Y |
| August 3, 2000 | Y | |
| August 8, 2000 | Y | |
| August 9, 2000 | | Y |
| November 3, 2000 | Y | |

A blank means the operation did not take place on that day.

The flow rates for entire plots were measured approximately weekly during the season whenever the system was operational. Totalizing flow meters were used on each plot to measure the amount of wastewater delivered during an approximately 30 minute test. Pressure was measured at the dripline inlets during each flow test. To account for the variation due to minor fluctuations of pressures from test to test, the calculated flowrates were normalized to the design pressure (Table 2) using the manufacturer's emitter exponent for that dripline type.

## RESULTS AND DISCUSSION

Of the five dripline types tested, the three higher-flow emitter sizes (0.40, 0.60, and 0.92 gal/hr-emitter) showed little sign of clogging (Fig. 1). Flow rates at the end of the test for those emitters were within 5% of the initial flow rates, indicating that very little clogging and resultant decrease of flow rate had occurred. The absence of clogging indicates that emitters of these sizes may be adequate for use with lagoon wastewater.

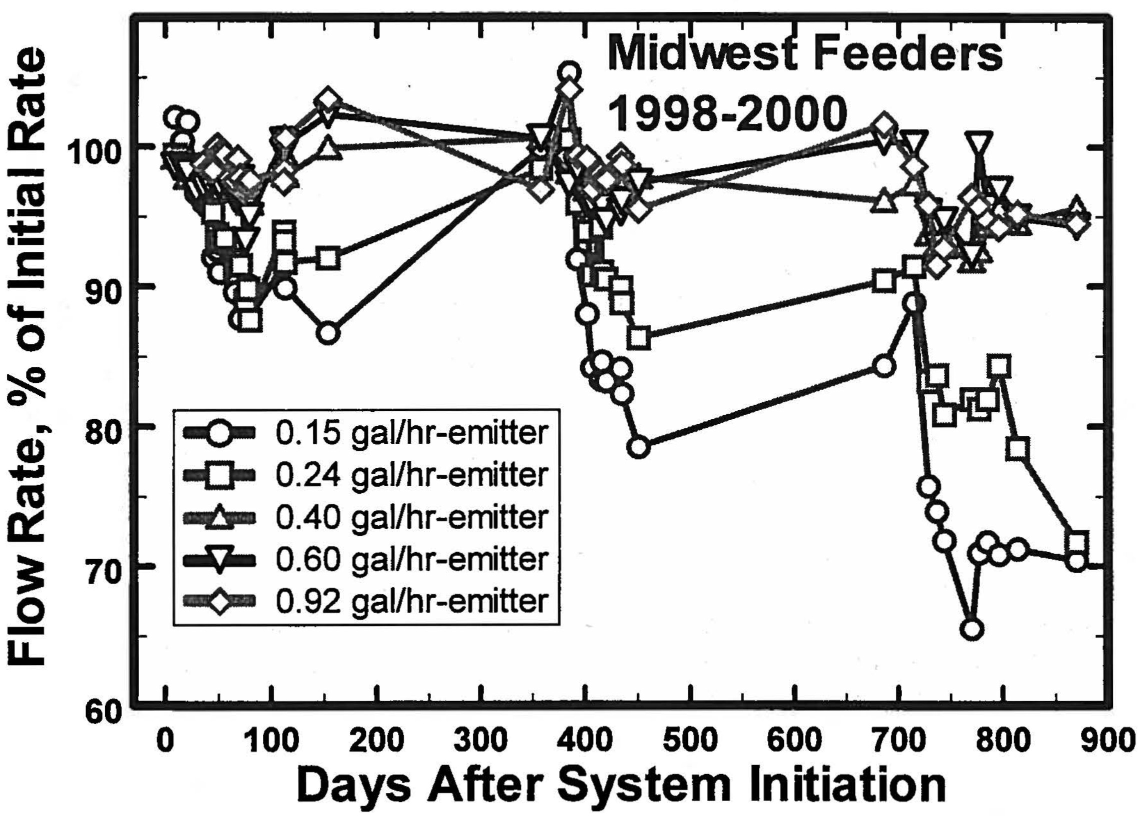


**Figure 1. Measured flow rates for five dripline types with different emitter flow rates using lagoon wastewater, Midwest Feeders, KS, 1998-2000.**

The two lower-flow emitter sizes (0.15 and 0.24 gal/hr-emitter) showed some signs of emitter clogging (Fig. 1) during all three growing seasons. Within 30 days of system completion in 1998, the flow rates in plots with both smaller emitter sizes began to decrease. The 0.15 gal/hr-emitter plots showed a gradual decrease of flow rate throughout the remainder of the season. By November 17, 1998 (Day 154), the flow rate had decreased by 15% of the initial rate. The 0.24 gal/hr-emitter plots showed a decrease in flow rate of 11% of the initial rate by September 2, 1998 (Day 78). Following harvest and the first (32-day) idle period, flow rates in the 0.24 gal/hr-emitter plots increased approximately 5% over the minimum measured rate. This increase indicates that some cleaning of the emitters had occurred in response to the flushing. The flow rate then stabilized for the rest of 1998 at about 9% less than the initial rate.

Following the winter idle period (Day 368), all flow rates recovered to near their initial flow rates (Fig. 1). Possible explanations for this include (a) the longer time that the acid and chlorine remained in the driplines allowed better control of biological clogging agents or (b) the cooler temperatures during the winter resulted in partial control of the biological clogging agents and the acid and chlorine were then more effective at cleaning up the remaining agents.

The smaller emitter sizes continued to have decreasing flow rates during the 1999 and 2000 growing seasons (Fig. 1), similar to the response in 1998. By the end of the third season (November 3, 2000, Day 870), flow rates had decreased by 30% in both of the smaller emitter sizes compared to the initial (maximum) flow rate.

The disk filter and automated backflush controller operated well in all thee years.

Excavation and visual inspection of dripline samples showed that flushing was effective in removing the accumulations of materials from the driplines. Prior to flushing, a slimy substance probably containing both silt and biological materials was present in the lines. After flushing, the driplines were clean.

Other management procedures might be employed to prevent performance degradation in the lower flow-rate emitters or remediate it after it occurs. Such procedures might include more frequent flushing, flushing with fresh water, and more frequent and concentrated chemical-injection treatments. However, the objective of this study was to compare the different driplines under difficult but identical conditions. Further studies are warranted to determine if the lower flow-rate driplines can be maintained at a higher performance level with more aggressive management.

These results show that the drip irrigation laterals used with SDI have potential for use with lagoon wastewater. However, the smaller emitter sizes normally used with groundwater sources in western Kansas may be risky for use with lagoon wastewater. The dripline performance was similar during all three growing seasons, but questions remain about the long-term, multiseason performance of SDI systems using livestock wastewater. Long-term reliable performance probably will be necessary to justify the high investment costs of SDI systems.

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