# DRIP DISTRIBUTION SOIL PERFORMANCE AND OPERATIONS IN A NORTHERN CLIMATE

by

Rachel M. Bohrer

A thesis submitted in partial fulfillment of

the requirements for the degree of

Master of Science

(Agricultural Engineering)

at the

UNIVERSITY OF WISCONSIN-MADISON

2000

Approved: James C. Converse

James C. Converse
Professor, Biological Systems Engineering
University of Wisconsin-Madison

Date: August 17, 2000

# CHAPTER 7: SUMMARY AND CONCLUSIONS

## 7.1 Soil Treatment

Six drip distribution systems in Wisconsin were studied to determine the treatment performance of the soil beneath the distribution network. Of the six systems studied, three received septic tank effluent (STE), one received effluent treated by a recirculating gravel filter (RGF) and the remaining two sites were treated by aerobic treatment units (ATU). Soil conditions varied at these sites, ranging from very coarse sand to clay loam. Three of these systems were on residential sites (1 STE, 2 ATU), one STE system served a rest area and the other served an elementary school. The RGF system served a seasonal campground. The depth of burial of the driplines ranged from 10-50 cm (4-20 inches) below the ground surface.

Six sets of soil profiles from each site were collected from below the drip distribution network throughout the summer of 1999. These soil samples were analyzed for fecal coliforms, *E. coli*, organic nitrogen, ammonium-nitrogen and nitrate-nitrogen. Six additional sets of soil profiles were collected from each site, adjacent to the distribution network, to determine the background levels of these parameters.

For all six systems studied, soil treatment of fecal coliforms and *E. coli* was very good resulting in concentrations at the level of detection at depths less than 90 cm (36 inches) below the dripline, regardless of soil or treatment type. For the 3 STE sites, with a median influent concentration of 140,000 colonies/100 ml, fecal coliform concentrations were below detection limits at depths greater than 45 cm (18 inches) below the dripline. *E. coli* results were similar for these systems.

The RGF site showed median fecal coliform concentrations below detection limits at depths greater than 75 cm (30 inches) below the dripline, with a median influent concentration of 870,000 colonies/100 ml. The system was demand dosed and overloaded, resulting in the chimney effect. *E. coli* results for this site were better, with concentrations at 1 or 2 MPN/gram of dry soil at depths greater than 15 cm (6 inches) below the dripline. Median *E. coli* concentration of the influent was 900,500 colonies/100 ml.

For the two ATU sites, fecal coliform and *E. coli* concentrations were very low throughout the profile. Based on median values, fecal coliform concentrations were at or below detection limits at depths greater than 2.5 cm (1 inch) below the dripline. The median fecal coliform concentration of the influent was also quite low at 250 colonies/100 ml. The median *E. coli* concentrations in the soil were at or below detection limits throughout the entire profile, with a median influent concentration of 100 colonies/100 ml.

Based on this research and using median values as the criteria, the separation distance for drip systems receiving STE could be reduced to 45 cm (18 inches). Systems receiving aerobically treated effluent with very low fecal coliforms (< 1,000 colonies/ 100 ml) and *E. coli* could have separation distances at < 30 cm (12 inches).

There is a significant difference in organic nitrogen concentration with depth, showing higher values at the shallower depths. This significant difference exists both beneath and adjacent to the systems. The only site that shows a significant difference in organic nitrogen between the profiles beneath the distribution network and those adjacent to it is the RGF site (Monroe County). This site consists of a very fine sand profile and was heavily loaded. For the remaining sites, the addition of wastewater to the system does not significantly effect the concentration of organic nitrogen in the soil.

The ammonium-nitrogen concentrations beneath the system were near background levels at all of the sites except for Barron, Monroe and Wood Counties (a rest area, a campground and a school, respectively). These three sites had higher influent ammonium-nitrogen concentrations than the other three sites, with medians ranging from 48 to 193 mg N/L. The wastewater from these three sites consisted mainly of toilet and sink water. These three sites showed a significant impact from ammonium-nitrogen on the soil system due to the addition of wastewater.

Nitrate-nitrogen concentrations in the soil, on a soil water basis, had median values ranging from 26-83 mg N/L of soil water at depths 90-105 cm (36-42 inches) below the dripline, regardless of treatment type. However, these values are similar to those found adjacent to the system. The high background levels are difficult to explain. The nitrogen impact from these systems was inconclusive due to the high, unexplainable background values.

### 7.2 Cold Weather Operation

Five drip distribution systems in Wisconsin were monitored to evaluate the performance of these systems in cold weather. Thermocouples were installed in various locations in the soil within the distribution network, as well as away from the active zones. Thermocouples measuring the ambient air and pump chamber effluent temperatures were also installed. These temperatures were recorded six times a day from December 1, 1998 through March 31, 1999 and from December 1, 1999 through March 14, 2000.

Despite two mild winters in Wisconsin, soil temperatures within the distribution network did drop below 0 C (32 F) and remained below this for several days. Soil temperatures at 10 cm (4 inches) below the depth of the dripline reached minimums of -1 C (30 F) in the southern portion of the state to -12 C (10 F) in the north. Periods of negative temperatures (Celsius) were sustained in the soil system for several weeks at a time at most sites. With these temperatures, none of the systems studied encountered operational problems due to the cold weather.

It is difficult to make generalizations as to the behavior of these systems under cold weather conditions because of the numerous variations between systems. From the temperatures observed in the soil, it is evident that the effluent being dosed provides some heat to the soil system. However, from the statistical analysis, it can be seen that there is no significant difference between the active and control zones at all but two of the sites. When analyzed by year (year x zone), however, there is a significant difference at most of the sites, which suggests that other factors may mask the significant effects of the addition of wastewater to the soil. The statistics also show no significant difference between the three depths. This suggests that the heat provided from the addition of wastewater also travels above and below the dripline, which can be seen in the soil temperatures observed. Some of this heat travels along the length of the dripline, which can be seen when comparing the data for temperatures at versus between emitters, and comparing these numbers with the control zones. However, this difference in temperatures is not significant at $p<0.05$.

From the results of this study, the potential of operational problems for drip distribution systems in northern climates does not appear to be a great concern under the conditions experienced during this study. However, the air temperatures were slightly above average for Wisconsin during this two-year study. There were several incidences in which the soil system surrounding the driplines sustained negative temperatures (Celsius) for extended periods of time. Regardless of these low temperatures, there was no occurrence of system malfunction due to the cold weather. With proper design and installation, drip distribution systems are an excellent alternative system for wastewater dispersal in cold climates.