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Project Summary

Infiltration Land Treatment of Stabilization Pond Effluent

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A rapid infiltration pilot wastewater treatment system consisting of three 0.07 hectare basins was operated for four seasons at Brookings, South Dakota. The objectives of the study were to demonstrate that rapid infiltration land treatment could upgrade stabilization pond effluent to meet stringent effluent requirements and to identify winter operating constraints for the system.

After passing through 1.3 m of the soil profile, the following quality was observed: BOD_5 was less than 4 mg/l all of the time and generally less than 2 mg/l; the suspended solids rarely exceeded 4 mg/l; total phosphorus rarely exceeded 1 mg/l; ammoniacal nitrogen was less than 2 mg/l and usually less than 1.1 mg/l; and nitrate nitrogen rarely exceeded 10 mg/l.

Winter operation of the pilot units with intermittent applications was not practical. Ice accumulated with each successive flooding and operation had to be discontinued in early January.

This Project Summary was developed by EPA's Robert S. Kerr Environmental Research Laboratory, Ada, OK, to announce key findings of the research report that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Stabilization ponds are the predominant type of treatment employed by municipalities of 5,000 persons or less in the Upper Great Plains Region. However, the ability of these ponds to meet present and future effluent standards is limited. A rapid infiltration system, designed and operated to make the maximum use of an available in-place soil, is considered as a potentially economical solution to meet future effluent requirements of stabilization ponds.

Of the 180 stabilization ponds operating in South Dakota, about 40 have not discharged for at least one year according to recent reports. These "no-discharge" facilities would actually be infiltration ponds in South Dakota since usual evaporation, precipitation and wastewater flow rates suggest an annual seepage rate in excess of 1.8 m (6 ft). Other ponds are also believed to exceed the 1.6 mm/day (1/16 in./day) allowable seepage rate. These losses to groundwater do not, however, imply contamination of groundwater since earlier studies revealed the seepage to be of excellent quality. The original objectives of this study were as follows:

1. Demonstrate the use of rapid infiltration land treatment as a means of up-grading existing secondary treatment to meet new effluent standards for BOD, suspended solids, and fecal coliforms while removing phosphorus and oxidizing ammonia nitrogen to nitrate to meet new ammonia standards;

2. determine acceptable loading rates for both a scarified and undisturbed silty loam soil, underdrained with perforated pipe at a

depth of 0.8 m (30 in.), for climatic conditions similar to those at Brookings, South Dakota; and

3. identify winter operating constraints imposed by the climatic conditions at this site.

Conclusions and Recommendations

System Description

The construction of the three pilot basins consisted of grading the soil surface to form dikes about 0.9 m (3 ft) high. Initially, dikes were constructed to enclose the middle basin without disturbing the existing soil and vegetal cover of alfalfa and brome grass. Additional dikes were formed to enclose two adjacent pilot units using the upper 0.2 m (8 in.) of soil. To prevent leakage and to define a measurable infiltration area, a plastic membrane was installed in the dikes and covered with a soil layer. The resulting three basins shown in Figure 1, about 15 m by 45 m (50 ft by 150 ft) in size, were designated as north, middle, and south for reference.

Perforated plastic underdrains were installed under each basin at a depth of about 0.8 m (30 in.) which was about 0.3 m (1 ft) above the natural ground water level at the time of construction. Unperforated plastic pipe was used to connect the underdrains to the sampling point.

Stabilization pond effluent was applied to the pilot system through 15 cm (6 in.) irrigation pipes (Figure 1). Meters recorded the flow to the units and float recorders monitored water-surface elevation in each basin.

Operation of the pilot basins during the summers of 1975 and 1976 involved once-per-week inundation. The south and middle basins were flooded with a volume equivalent to 0.6 m (24 in.) each week while the north basins received 0.45 m (18 in.) per week.

In 1977 a second, deeper underdrainage system was installed in the basins at a depth of about 1.3 m (4.5 ft) in an effort to improve the nitrogen removal capability of the unit. Both underdrain systems were connected to a new, deeper sampling box.

In 1977, all three basins received a weekly total of 0.6 m (2 ft) of wastewater. However, instead of one flooding per week, 0.2 m (8 in.) of water was applied to the basins each Monday, Wednesday, and Friday. In 1978, the basins were operated much the same as in 1977.

Loading Rates

Loading rates of 0.6 m/week (24 in./week) were easily maintained from spring through fall when single weekly wastewater applications were used. When the soil was sustained in a near-saturated condition, infiltration rates diminished from about 15 mm/hour (0.55 in./hour), the rate representative of an eight-day test, to about 3 mm/hour (0.1 in./hour). Equilibrium loading rates for a nearly continuously wetted area would be about 45 cm/week (18 in./week) for the scarified basins compared to 60 cm/week (24 in./week) for unscarified soils containing the highly organic surface layer.

Groundwater Response

To illustrate the response of the groundwater under the basins during a flooding cycle, cross sections were prepared of the water level at various times before and after the weekly wastewater applications (Figure 2). Four-week averages of piezometer readings during the summer period of July 20 - August 10, 1976, were selected as representative. The water level represented by the 10:00 p.m. reading of the piezometers on the day of flooding is probably near the maximum groundwater height following a flooding. The usual procedure of applying wastewater to the basins in a south-middle-north sequence required about 11 hours in 1976 starting about 7:00 a.m. At that time a water depth of about 40 cm (1.3 ft) was being attained on the north and south basins when flooding was completed. Those two basins were empty about 20 to 30 hours later while the middle basin emptied in about 8 hours. About 2 days after flooding started, the ground water had reached near normal levels. In the remaining 5 days before flooding resumed, groundwater under the basins was lowered an additional 0.3 m (1 ft) to exhibit the "dished-out" profile just before the flooding cycle was repeated.

Effluent Quality

The analytical data obtained for periods of operation from 1975 to 1978 are summarized as mean concentrations in Table 1. During each season, the effluent from the stabilization pond experienced wide variations in quality. The infiltration basins, however, have produced effluents of far more uniform quality, and each successive year has generally demonstrated an improved quality of effluent.

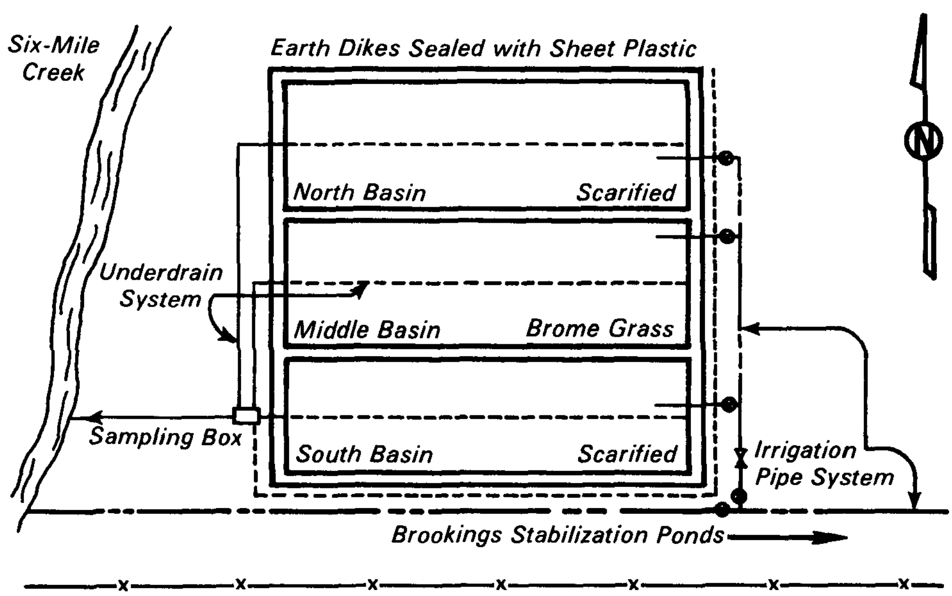

Figure 1. *Layout of the pilot unit showing three basins, application system, and drainage system to Six-Mile Creek as constructed in 1976.*

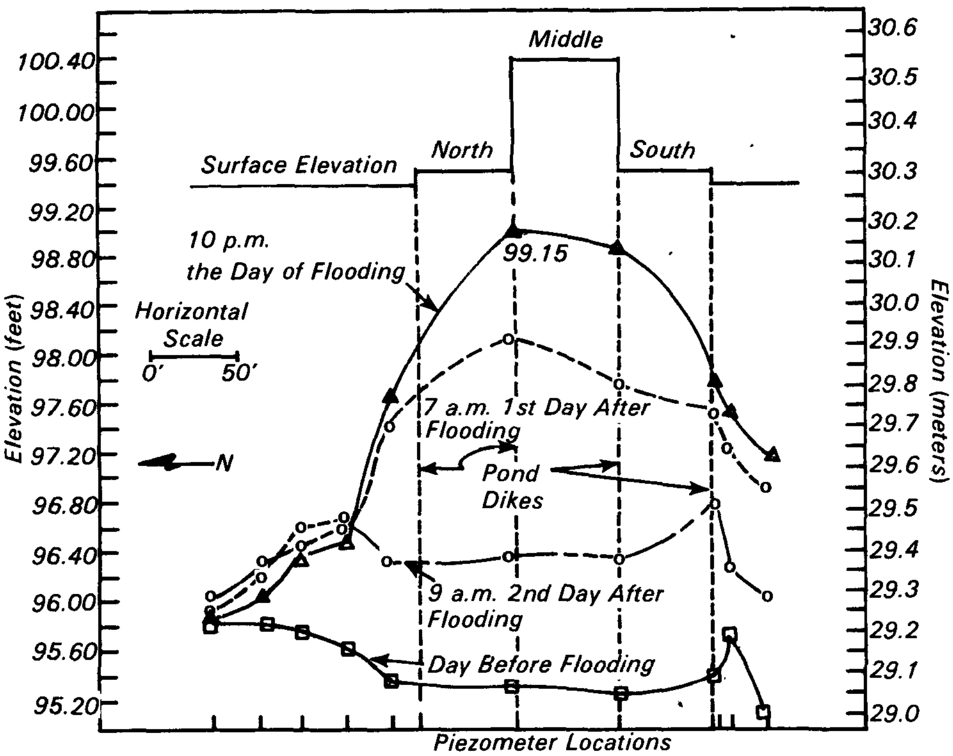

Figure 2. *Groundwater elevations on a center north-south cross section of the infiltration basins at four times during a flooding cycle, 1976.*

Table 1. *Mean Quality of Influent and Renovated Water 1.3 m Below Surface*

Parameter		*Influent*	*North*	*Middle*	*South*
BOD_5	*mg/l*	*21.0*	*1.1*	*1.7*	*1.2*
Suspended Solids	*mg/l*	*27.0*	*1.9*	*2.4*	*1.7*
Conductivity	*μ mhos-cm^{-1}*	*1900.0*	*2000.0*	*2000.0*	*2000.0*
Ortho Phosphorus	*mg/l*	*2.8*	*0.2*	*0.4*	*0.3*
Total Phosphorus	*mg/l*	*3.4*	*0.3*	*0.5*	*0.3*
Ammonia Nitrogen	*mg/l*	*10.0*	*0.7*	*0.6*	*1.0*
Nitrate Nitrogen	*mg/l*	*0.8*	*1.0*	*4.2*	*1.4*
Kjeldahl Nitrogen	*mg/l*	*13.0*	*1.2*	*1.1*	*1.5*
pH	*mg/l*	*8.0*	*7.4*	*7.4*	*7.4*

Nitrogen Control

Initially, the major nitrogen concern was for reductions in ammonia nitrogen (NH_3-N) concentration. With a high water table situation, renovated water was collected and pumped to a surface water stream. Effluent limits of NH_3-N were the result of a continuous 1.0 mg/l or less in-stream allowable concentration for fish propagation waters. In South Dakota, virtually all streams are classified fish propagation waters. In 1977, the stream standard was changed to 0.02 and 0.04 mg/l un-ionized ammonia which requires pH and temperature data to measure compliance. Since most South Dakota streams flow intermittently, the effluent permits for ammonia have stipulated very low concentrations, 1.5 mg/l for Brookings in 1976. Oxidation of the NH_3-N to nitrate nitrogen (NO_3-N) appeared to be an acceptable solution to the ammonia limitations since discharge of treated wastewater to lakes is not permitted in South Dakota.

The concentration of NH_3-N of the stabilization pond effluent (influent to the pilot unit) comprised the major fraction of the total nitrogen and was far in excess of the 1.5 mg/l allowable NH_3-N standard. In the basin drain effluents, NH_3-N concentrations were frequently reduced to below the 1.5 mg/l limit particularly after 1975 when direct short-circuiting to the drains was evident. In 1977 when three wastewater applications per week provided the weekly loading, NH_3-N was consistently reduced to below 1.5 mg/l in the lower drains. From the upper drains, particularly from the middle basin, this limit was still frequently exceeded. With the pH of the effluent about 7.5 and temperature about 18°C, meeting the limits for un-ionized ammonia was virtually assured.

The concentration of nitrates in the effluent from the pilot basins was the second concern of the study. Although the shallow water table made possible the collection of renovated water and discharge to the nearby stream, only a portion of the renovated water was pumped to the stream. High concentrations of nitrate could become a quality threat to drinking water supplies, particularly when similar large facilities are less suitably located with respect to major aquifers. Consequently, both ammonia and nitrates concentrations were of concern in the effluent from the infiltrations basins. Control of both these nitrogen forms led to a desire to accomplish total nitrogen removal.

Figure 3 shows the mean nitrogen concentrations for influent (stabilization pond effluent) and the north, middle, and south drain effluents from the pilot unit for the period from 1975 through 1978. The relative concentrations of ammonia, nitrate, and organic nitrogen are also shown.

Figure 3 shows that the total nitrogen discharged from the pilot basins was almost identical to that of the influent in 1975 and 1976. During these years with one-per-week wastewater applications, increases in nitrates

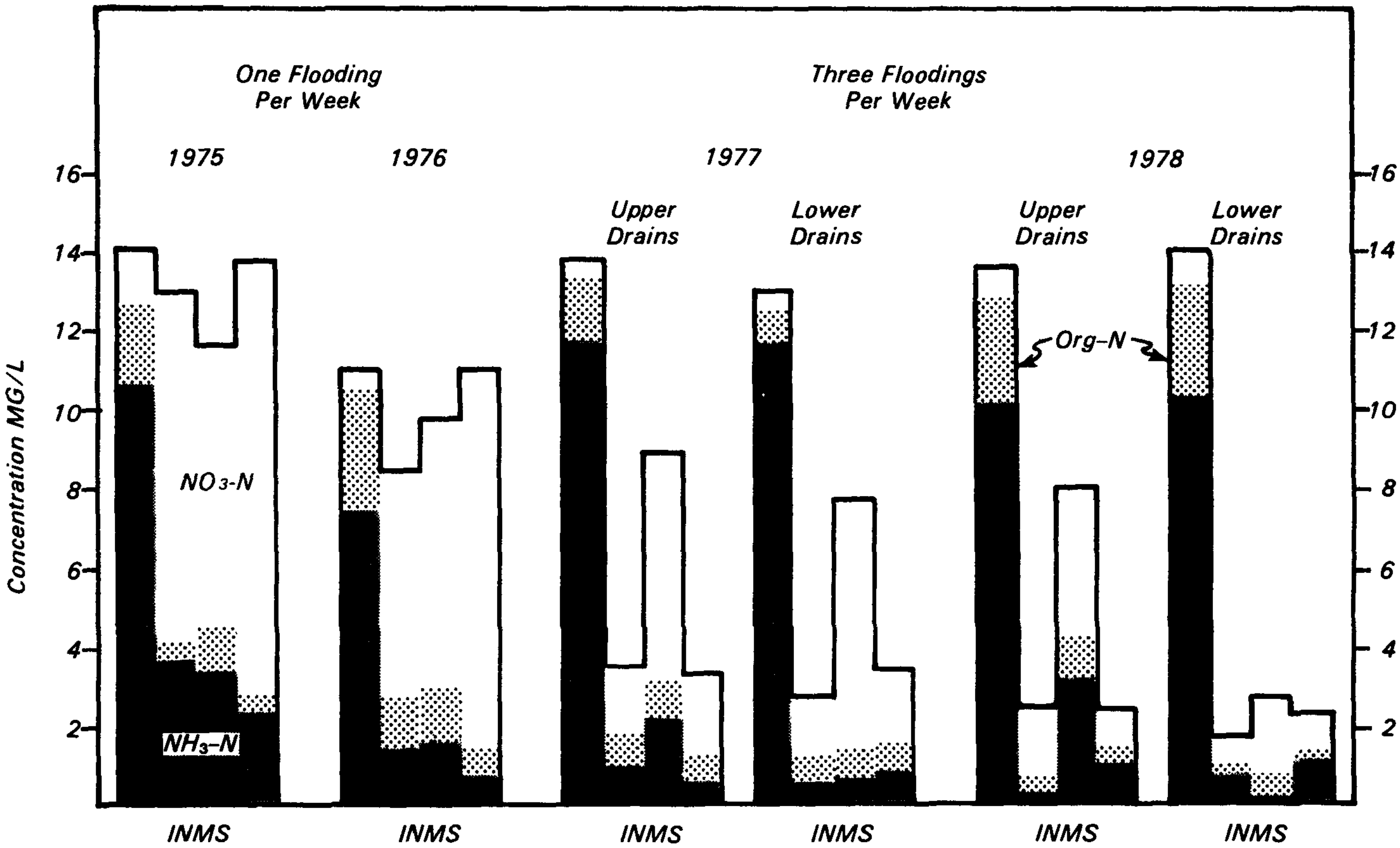

Figure 3. *Annual mean nitrogen concentrations for influent (I), north (N), middle (M), and south (S) drain effluents for infiltration basins, 1975-1978.*

accounted for the reductions of ammonia. By contrast, in 1977 and 1978 when more frequent wastewater applications prevented effective aeration of the soil, nitrate and total nitrogen in the drain effluents was reduced significantly. The exceptions were the effluents from the middle basin where a much higher infiltration rate resulted in intermittent drying and aeration of that basin.

A rather wide range of concentrations of the various nitrogen forms was noted throughout each of the four years of operation. For the stabilization pond effluent (influent), NH_3-N usually was the major component with substantial concentrations of organic nitrogen and comparatively small quantities of nitrate. Nitrate -N was predominant in the drain effluents followed by ammonia -N and organic -N.

Winter Operating Constraints

Continuous operation of infiltration-percolation systems, even in northern climates, has been considered as one of the major advantages of this type of land application system. Where winter operation has been practiced effectively, the wastewater has been applied periodically in some cases to infiltration basins. In other instances, the water levels have been maintained in the basins so that seepage has been on a more-or-less continuous basis. The wastewater has generally been applied to the basins shortly after biological treatment, usually with trickling filters. Consequently, the wastewater probably was warm enough to prevent the soil from freezing under an ice cover.

Application of wastewater from the stabilization pond did not prove to be effective for melting the snow and ice accumulations. During winter, the wastewater as it came from the stabilization pond was already near a freezing temperature. At other facilities where winter operation has been reported, warmer effluents from secondary treatment plants have been applied directly to the land. At Brookings, the temperature of the effluent of the trickling filter plant is near 19°C (50°F), even through the most severe winter month of January. With a full-scale system, the effluent of this plant might be applied with more success directly to infiltration basins during the winter.

The entire winter period when wastewater was not applied during the 1975-76 winter was from early January to early April, a period of less than three months. The April inundation of the pilot units was undertaken to verify that wastewater could be applied and treated by that date although visual observations indicated that wastewater could have been applied at an earlier date. The quality of the effluent for that particular flooding, however, was poor and apparent short-circuiting was evident.

From observations and experience during the winter operations, it appeared that the ice problems that occurred with the stabilization pond effluent would not be overcome with operational changes at the existing pilot basins. Wastewater applications were continued into December although reduced volumes were applied because of accumulated ice. Historically, the annual average air temperature in the Brookings area drops to freezing about November 12, so it would appear that wastewater applications from stabilization ponds could safely continue on a regular basis for at least a month beyond that date. Consequently, existing stabilization ponds in South Dakota which are frequently designed with six months of detention could probably be operated to provide both the preapplication treatment and the necessary emergency storage capacity to carry through the most severe winters.

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***Carl G. Enfield** is the EPA Project Officer (see below).*
The complete report, entitled "Infiltration Land Treatment of Stabilization Pond Effluent," (Order No. PB 82-109 919; Cost: $8.00, subject to change) will be available only from:
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