U. S. FOREST SERVICE

RESEARCH NOTE NC-197

NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE
Folwell Avenue, St. Paul, Minnesota 55101

1976

SEWAGE EFFLUENT INFILTRATES FROZEN FOREST SOIL

Alfred Ray Harris, *Soil Physicist*
East Lansing, Michigan

ABSTRACT.--Secondarily treated sewage effluent, applied at the rate of 1 and 2 inches per week, infiltrated a frozen Sparta sand soil forested with jack pine and scrub oak. Maximum frost depth in treated plots averaged 60 cm and in check plots averaged 35 cm. Nitrogen was mobile with some accumulation. Phosphorus was absorbed.

OXFORD: 114.123:U628.36. KEY WORDS: winter irrigation, effluent irrigation, permeability.

Disposal of sewage effluent on land holds promise as a means of reclaiming a valuable resource and reducing stream contamination. However, special problems are encountered in winter with application, distribution, and renovation of sewage effluent in areas where hard freezing occurs.

Cultivated land is usually impervious when frozen. However on forested land water has been found to infiltrate frozen soil (Nazarov 1969, Sartz 1969, Harris 1972). Although infiltration may be limited, the larger macropores and biopores (openings due to biological activity) are capable of conducting water throughout the frost season (Krumbach and White 1964, Harris 1972).

Infiltration of water through forested soils has been studied on the more fertile, fine-particled soils where biopores are well established. But many of the forested soils where effluent might be applied are sandy, fairly sterile, and have a less obvious biopore volume so we ran a pilot study to see if frozen forested sand soils could conduct water.

Twelve plots, 9 feet square, were established in a forested area near the Fort McCoy, Wisconsin, sewage treatment plant. Vegetation was jack pine (*Pinus banksiana*) intermixed with scrub oak. The soil was a Sparta sand with an average surface organic matter content of 2 percent. The treatments consisted of 1 and 2 inches of sewage effluent applied each week. Each treatment had four replications and there were four check plots. Secondary sewage effluent was pumped from the chlorination tank through polyethylene pipes to 55-gallon drum reservoirs located next to each treatment plot. The plots were flooded through a water spreader tube at the rate of 5 inches per hour.

Three frost tubes to measure frozen soil depth and two ceramic cup water samplers were installed in each plot at 15-cm and 60-cm depths to collect soil-water samples beneath the frozen zone. Soil frost and snow depth were measured weekly on all plots. A set of soil-water samples was taken late in February and at the end of the frost period in March. The average temperature of the applied effluent was approximately 34°F.

Effluent infiltrated most of the plots throughout the winter, although infiltration was restricted for short periods of time on half the treated plots. One 2-inch per week plot was completely sealed with ice by late

February and infiltration on another 2-inch per week plot and two 1-inch per week plots was noticeably restricted. However, by late March, when the surface 15 cm of soil had thawed, the infiltration rate increased noticeably in all restricted plots.

In early winter, frost was deepest in the check plots, probably because the irrigated plots received additional heat from the effluent, which was applied beneath the insulating snow cover. The snow melted in January exposing the soil surface. Much deeper frost then formed in all plots, especially in the irrigated plots (fig. 1). Because of the scant snow cover, frost

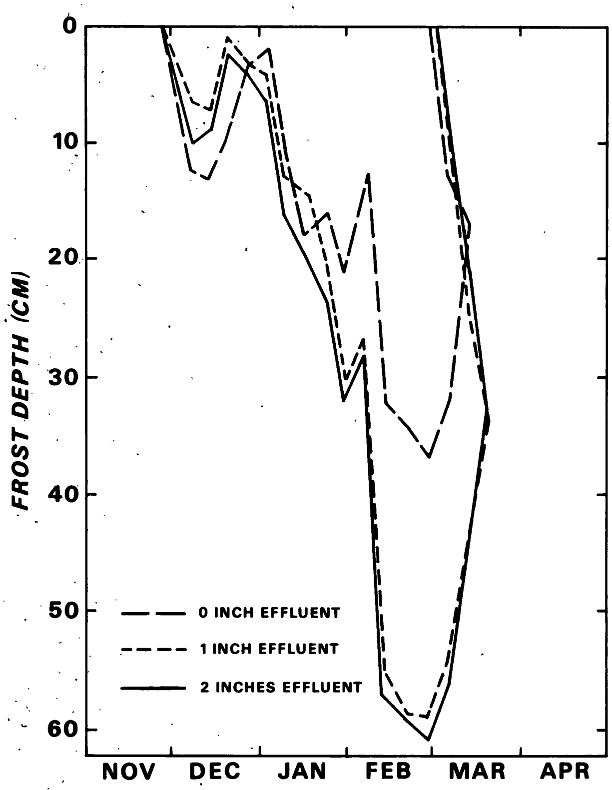

Figure 1.--*Average soil frost depth in plots with different sewage effluent application rates for winter 1972-1973.*

depth reacted quickly to weather changes. Frost depth was not influenced by effluent application rate. Heat transfer reached its maximum at the 1-inch-per-week irrigation rate. Frost reached an average depth of 60 cm in treated plots and 35 cm in the checks.

The effluent was low in nutrients, having an average total nitrogen content of 0.43 mg/l and an average total phosphorus content of 0.31 mg/l. Treated plots contained more nitrogen than untreated plots. More nitrogen accumulated under the 2-inch-per-week than the 1-inch-per-week application rate, as would be expected. Nitrate-N was not determined, so it is not known in what form the nitrogen moved through the profile. It is doubtful any nitrogen transformation took place below freezing. Evidently, all the applied phosphorus was absorbed.

It is evident that, even though infiltration may be partly restricted for part of the winter, considerable sewage effluent can infiltrate a deeply frozen sand soil in this forest type. Nitrogen does move through this soil during the freezing season.

LITERATURE CITED

Harris, Alfred Ray. 1972. Infiltration rate as affected by soil freezing under three cover types. Soil Sci. Soc. Am. Proc. 36: 489-492.

Krumback, A. W., Jr., and D. P. White. 1964. Moisture, pore space, and bulk density changes in frozen soil. Soil Sci. Soc. Am. Proc. 28: 422-425.

Nazarov, G. V. 1969. Water permeability of frozen soils in the central chernozem province. In Soviet Hydrology: Selected Papers 1, Am. Geophys. Union, p. 79-84.

Sartz, Richard S. 1969. Soil water movement as affected by deep freezing. Soil Sci. Soc. Am. Proc. 33: 333-337.

☆U. S. GOVERNMENT PRINTING OFFICE: 1976--668914/104 REGION NO. 6