Land Treatment of Wastewater a Natural Alternative

FOREWORD

One of the Nation's major environmental problems is the treatment and the disposal of municipal wastewater. Today, high treatment standards are required, but at the same time wastewater renovation methods must be reasonably economical and energy-efficient. To find better methods of renovating municipal wastewater, the U.S. Army Corps of Engineers has conducted an extensive research program on the land treatment of wastewater.

As the Nation's primary agency for water resources development and management, the Corps is vitally concerned with preventing the pollution of national waters. The Corps is responsible for the management of 5.7 million acres of land and 4.9 million surface acres of water and is committed to preserving the quality of these areas for the citizens of the United States.

This brochure presents some highlights of the Corps' Land Treatment of Wastewater Program. We are proud to have helped to develop this waste treatment alternative.

J.W. Morris
Lieutenant General, USA
Chief of Engineers

INTRODUCTION

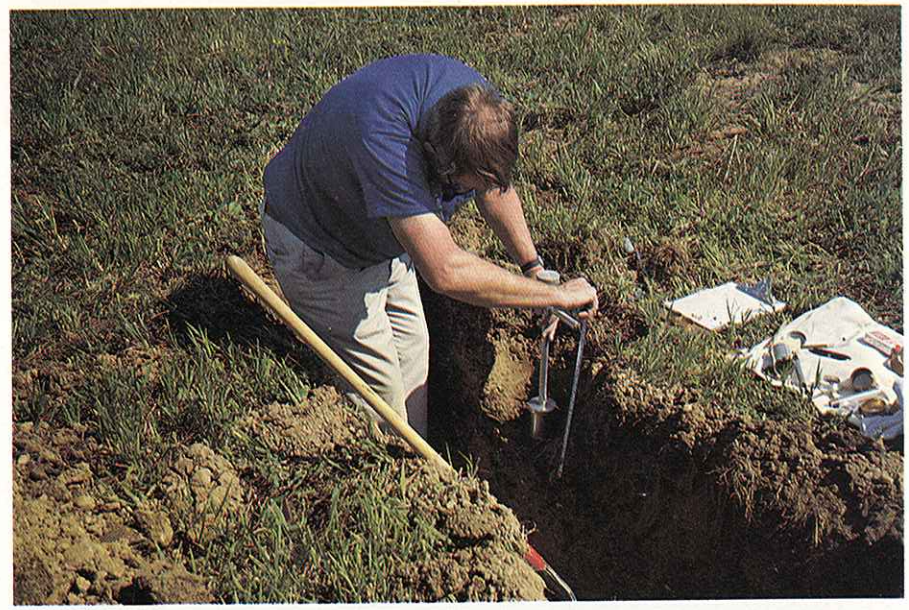
The problem of waste disposal is virtually as old as civilization. In the past, wastes were often simply discharged into bodies of water, but the adverse environmental effects of such practices have become increasingly apparent as populations have grown.

Today, the treatment and disposal of municipal wastewater is one of our major environmental concerns. Each day more than 95 billion gallons of wastewater are produced in the United States, and the discharge of partially treated or raw wastewater has frequently resulted in pollution of the soil and groundwater, and of lakes, rivers, estuaries and other natural waters. In addition, the failure of treatment plants to remove toxic materials can result in the accumulation of these substances in the food chain.

The Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500) and the Clean Water Act of 1977 (Public Law 95-217) established national goals to eliminate the discharge of pollutants into navigable waters to protect public health and preserve the fish, shellfish and other wildlife in these waters. But conventional sewage treatment plants have been generally inadequate to meet these goals. Two alternatives have been available: the addition of sophisticated waste treatment processes to conventional plants or the *land treatment of wastewater*.

Land treatment of wastewater uses plants and soil to remove undesirable waste constituents through natural processes. Though the application of wastewater to land is certainly not a new concept—evidence of such systems dates back more than 2000 years—the scientific use of the land to treat wastewater is a relatively new technology.

Land treatment of wastewater has shown many advantages over conventional methods for treating municipal



Testing soil at land treatment site

Spray irrigation of wastewater

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wastewater. In many instances it can do a better job of renovating wastewater at a substantially lower cost than can conventional systems. Often highly skilled operators are not required to run land treatment systems. In systems where the water is not collected after treatment by the land, the need for a discharge permit is eliminated. In addition, land treatment helps to maintain the water table in dry areas and can greatly increase yields of forage crops for livestock.

In 1971, the U.S. Army Corps of Engineers began a series of comprehensive regional wastewater management studies and identified land treatment as a promising treatment alternative for the renovation of municipal wastewater. But it was clear that neither the Corps nor the general engineering community had the expertise to routinely design land treatment systems.

As a result, the Corps began the Land Treatment of Wastewater Research Program and designated CRREL (the U.S. Army Cold Regions Research and Engineering Laboratory, in Hanover, New Hampshire) as its lead laboratory. The objective of this program has been to convert the former trial and error approach for designing land treatment systems into a proven and reliable engineering technology.

Measuring water infiltration rate

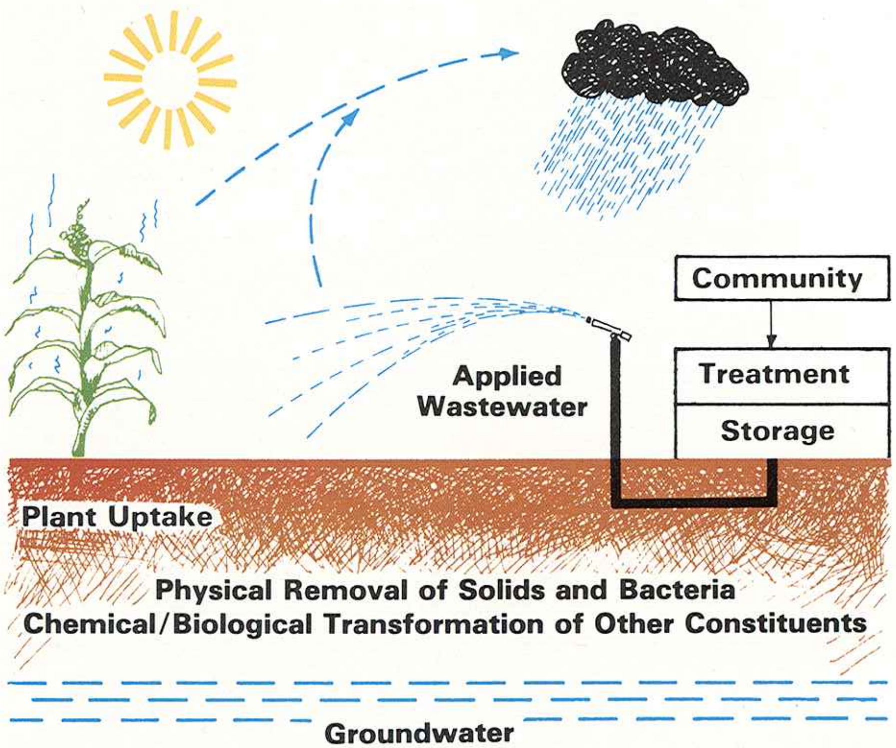
THE RESEARCH PROGRAM

The research has focused on developing technically and economically feasible methods of planning and designing wastewater land treatment systems. Basically, a typical land treatment system can be considered to consist of three major operational components:

First, there will generally be some type of facility for pretreating the raw wastewater.

Second, a storage reservoir must be built to contain the wastewater during periods of inclement weather or mechanical failure.

Third, there must be a land treatment area where the wastewater is renovated as it moves through or over the soil.

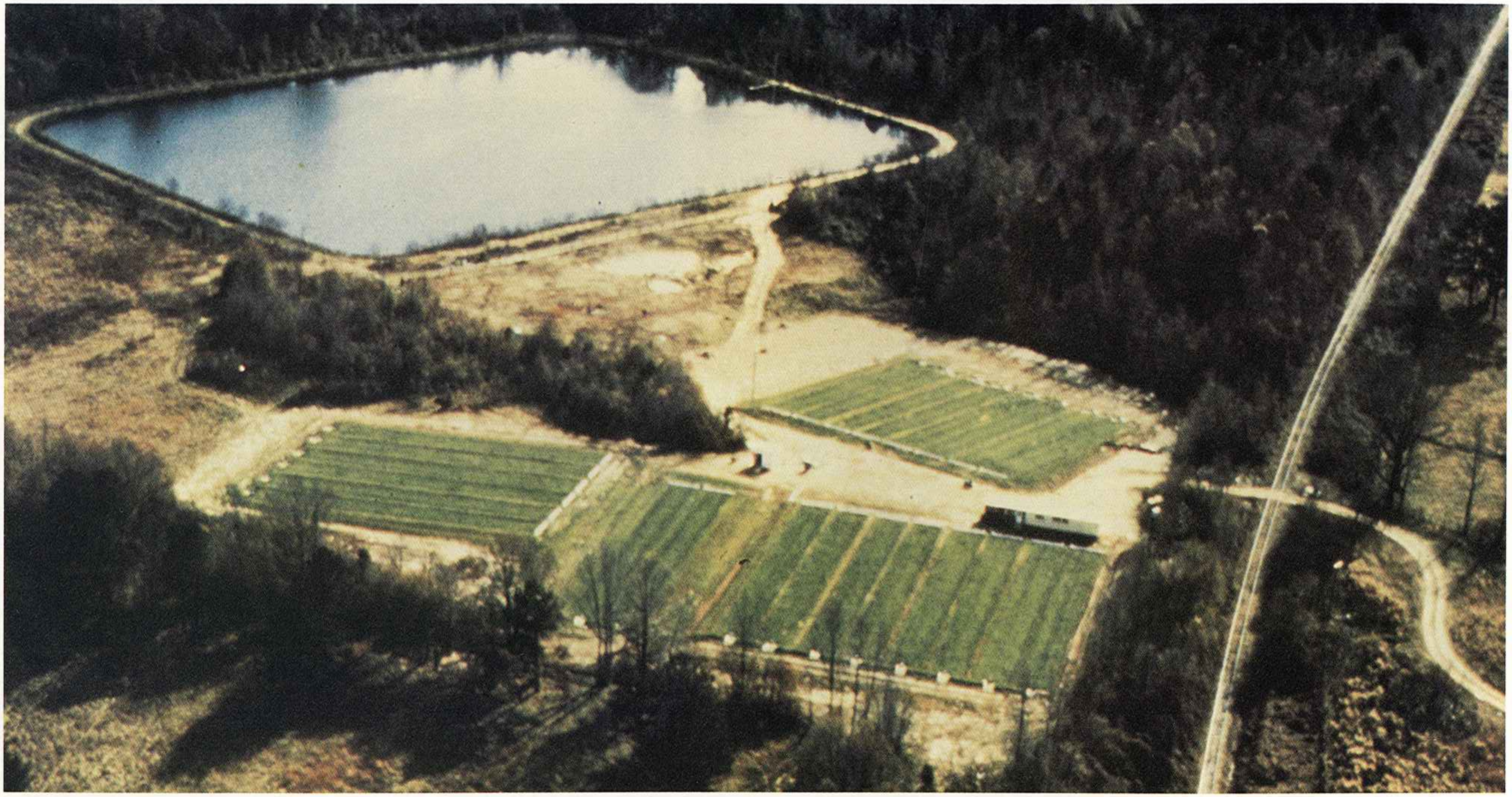


Concept drawing of how land treatment renovates wastewater

Research area at CRREL in Hanover, New Hampshire

Along with studying these basic components, investigations have been made of their interaction in the three major types of land treatment systems: (1) overland flow, (2) slow rate, and (3) rapid infiltration. As indicated by their names, these three types vary as to the rate at which the wastewater is applied and the way that it is renovated after application to the land.

In an *overland flow* system, wastewater is applied to the top of gently sloping, grassy terrain and is renovated by natural processes as it flows over the soil. The renovated wastewater that remains after evaporation and transpiration by plants is collected at the bottom of the slope and



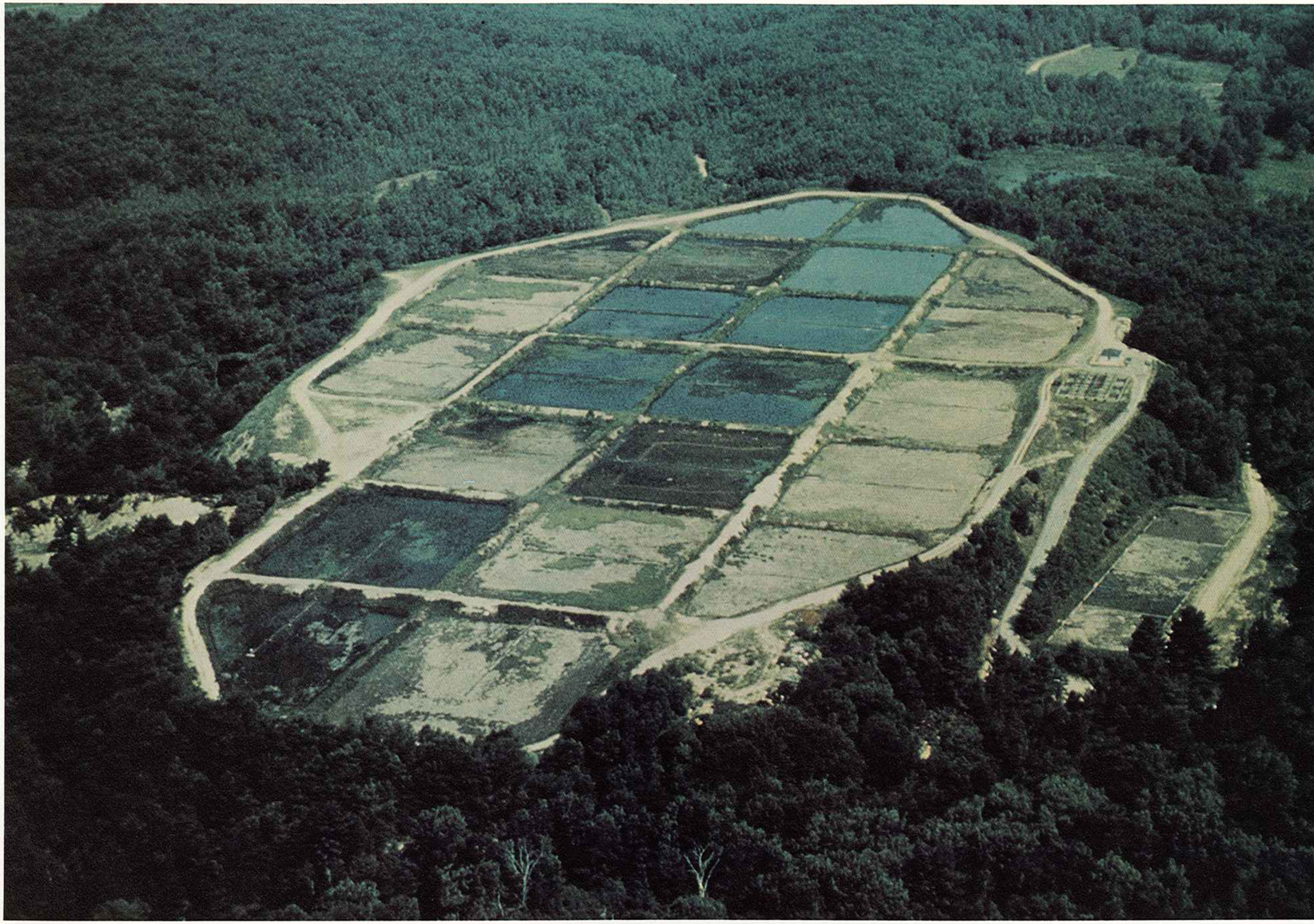
Overland flow system at Utica, Mississippi discharged. This method of land treatment has been tested by constructing and operating a small overland flow system in Hanover, New Hampshire, and by studying a somewhat larger system in Utica, Mississippi.

A *slow rate* system applies wastewater to tracts of vegetated land so that the wastewater percolates into the soil. The slow rate process has been tested by constructing six large outdoor test cells (pictured on the back cover) where the wastewater can be sampled and analyzed as it moves through the soil. These cells have been covered with forage grasses and tested on a year-round basis. There are now seven years of record showing exactly what went onto the land and what came off.

In a *rapid infiltration* system, the wastewater is applied to highly permeable soils, such as sands or sandy loams, in large treatment basins and is renovated as it travels through the soil. Rapid infiltration has been studied by monitoring treatment plants of this type in Michigan, Massachusetts (see photo on next page) and New York.

Research has also been conducted at 14 other land treatment systems located throughout the United States. Cooperative studies with the Environmental Protection Agency, the Department of Agriculture's Science and Education Administration, the U.S. Army Engineer Waterways Experiment Station, and the U.S. Army's Medical Bioengineering Research and Development Laboratory, as well as with 15 different universities and state governmental agencies, have greatly increased the understanding of how these systems operate.

Experimental slow rate system at Apple Valley, Minnesota



Rapid infiltration system at Fort Devens, Massachusetts

RESULTS

The research has demonstrated the cost-effectiveness of land treatment and the high quality of this wastewater renovation process. Although the construction costs of land treatment and conventional wastewater treatment plants may be similar, the operation and maintenance costs of land treatment systems have usually been found to be lower for the same level of performance. In general, land treatment systems consume less energy than conventional plants because they do not require massive aerators and sludge processing equipment. In addition, land treatment systems can often achieve superior performance in removing harmful waste components.

Land treatment has been found to pose no greater risk to workers or to the adjacent population than any other form of waste treatment. Among other studies, this was demonstrated by the results of a controlled study of bacterial transmission at a spray irrigation site. Several analyses have been made of the concentrations of "heavy metals" in the plants growing at land treatment sites where domestic wastewater is applied. The results have shown that the levels are sufficiently low to pose minimal danger when the plants are used for animal forage.

The relationship between the amount of wastewater applied and the removal of nitrogen and phosphorus compounds from the wastewater has been extensively studied. In many cases, the removal rate of nitrogen will determine the rate at which the wastewater can be applied to the land. Studies with a stable tracer isotope of nitrogen have been conducted to account for removal of this element at all stages of the wastewater treatment process. Computer models describing the fate of nitrogen and phosphorus have been constructed so that the many variables involved can be easily analyzed. Phosphorus removal by slow rate

Collecting grass samples from test cell land treatment systems has generally been found to be excellent.

The research has also revealed important results with respect to the major operational components of a land treatment system (pretreatment, storage and land application).

With respect to pretreatment, the studies have shown that only primary treatment of wastewater—settling to remove larger solids—is necessary before applying it to the land in areas where public access is restricted. Certain methods of secondary treatment can be a hindrance to good renovation in land treatment. By not requiring extensive treatment of the wastewater before it is applied, large savings can result in both the cost of constructing a system

Checking aerosol samples at Deer Creek Lake system and in its operation and maintenance.

With respect to storage, research has shown that storage requirements in most cases have been greatly overestimated. Wastewater can be renovated during much of the winter even at northern land treatment sites, so that the size of storage ponds can be minimized. This finding can result in an extensive savings in both the cost of constructing the storage facility and in reducing the size requirements for the spray field.

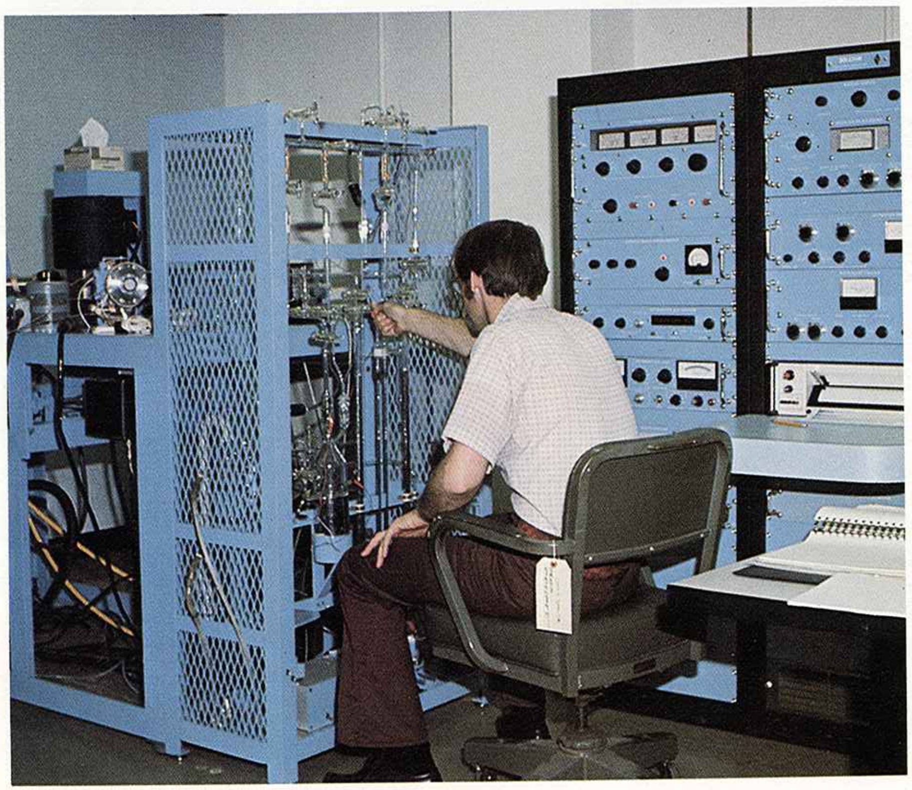
A number of important results have been obtained that apply to improving the process of land treatment itself. Studies at CRREL and at Apple Valley, Minnesota, have shown the fertilizing benefit of wastewater when it is applied to fields where crops are grown. Growing dual crops—planting rye in the fall and then tilling strips in the rye and planting corn in the spring—has helped to maintain the infiltration capacity of the soil, increase nitrogen removal, and lengthen the application season. The growth of the crops on these plots has been 20-30% higher than on farms in the surrounding area that have used commercial fertilizer.

Likewise, research on wastewater application to forests has shown both a high treatment level and a substantial increase in the growth rate of the trees in experimental areas.

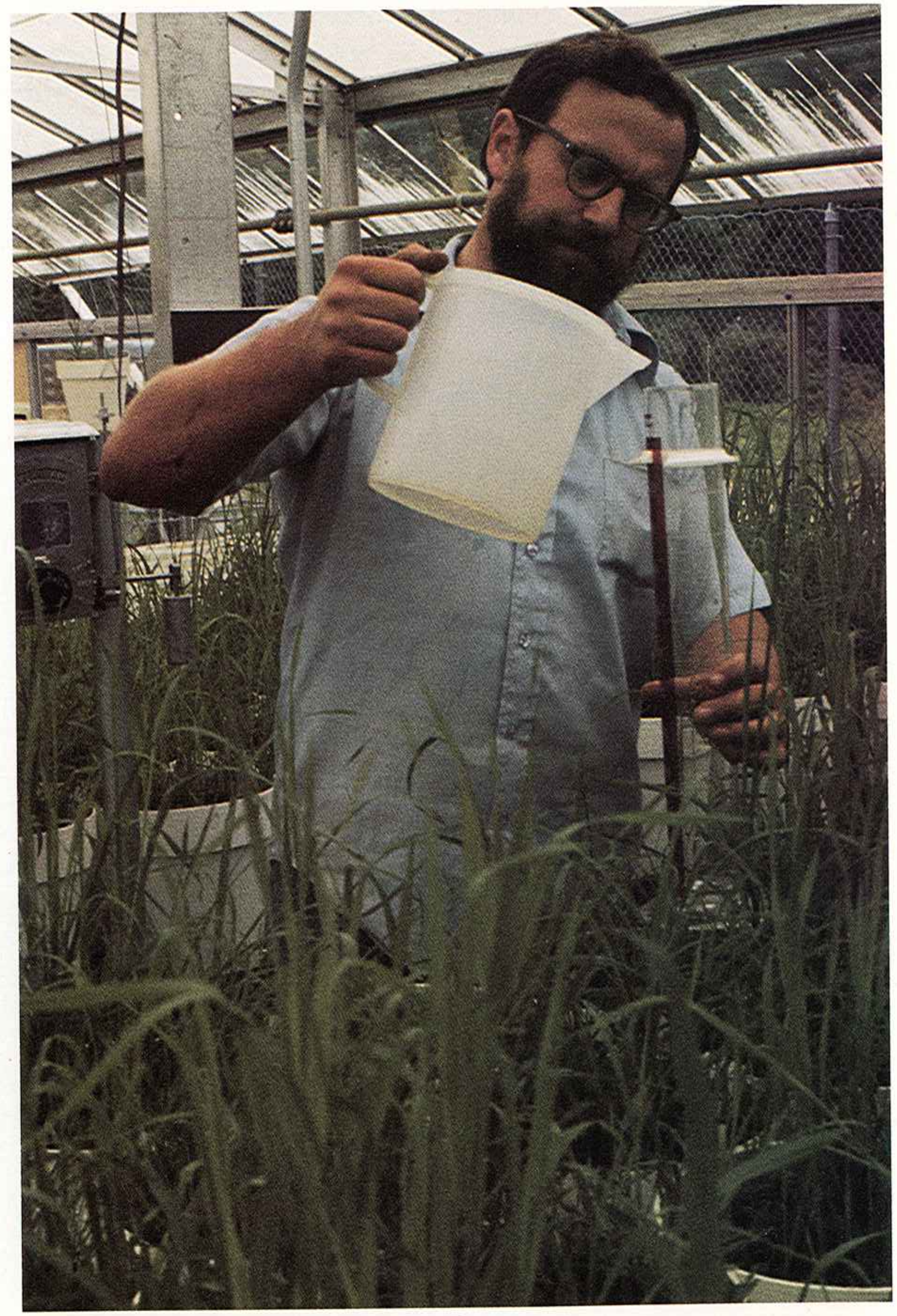
Winter application of wastewater at West Dover, Vermont

APPLICATIONS

Perhaps the most important result of the Land Treatment of Wastewater Research Program will be to enhance the design of new systems and to upgrade the operation of existing systems. It is now possible to design land treatment systems with rational engineering criteria. A major step in this direction was the publication by the Corps of Engineers, the Environmental Protection Agency and the Department of Agriculture of the *Process Design Manual for Land Treatment of Municipal Wastewater* (COE EM 1110-1-501, EPA 625/1-77-008). Another important step was



Testing sample with mass spectrometer



Applying wastewater in greenhouse study the International Symposium on Land Treatment of Wastewater that attracted participants from throughout the world.

Over 170 technical reports have been written on the various aspects of land treatment and are available to the public. In addition, numerous requests for information have been answered and a computer-assisted procedure for design and evaluation of land treatment systems has been developed. The results of the research program have been significant, and the Corps is helping the Environmental Protection Agency to prepare a revised version of the *Design Manual* for publication in 1981.

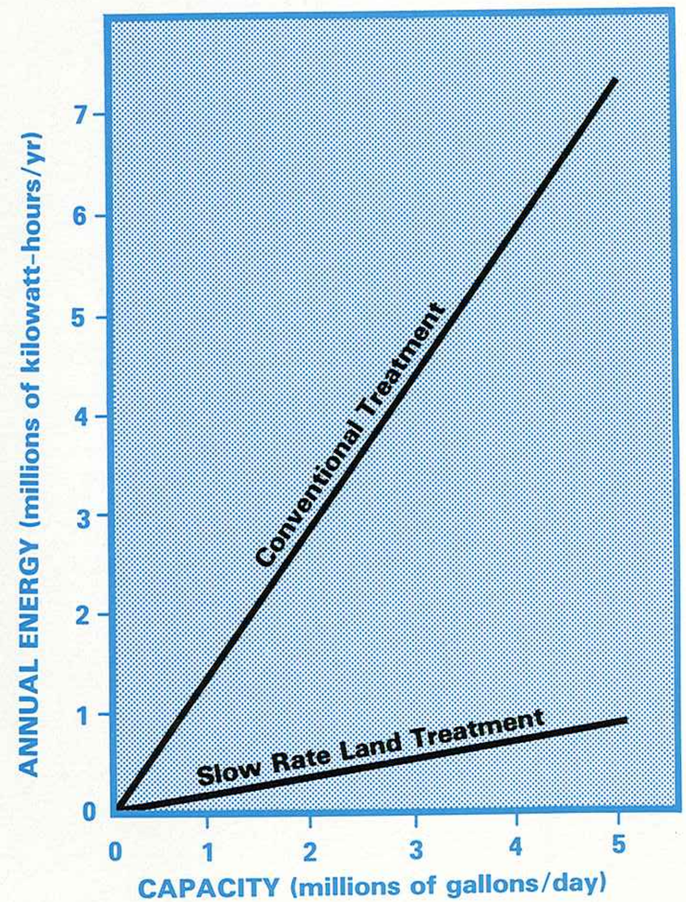
Cattle grazing on forage irrigated with wastewater

CONCLUSIONS

The Corps' Land Treatment of Wastewater Program has shown this treatment method to be an attractive alternative to conventional waste treatment practices. Land treatment can be more economical and more effective in removing pollutants than conventional techniques. When suitable land is available, land treatment can be adapted to nearly any site, and potential problems can be eliminated by proper design and management.

In addition, land wastewater treatment systems have shown the capability of producing forage crops and helping to restore the groundwater table, especially in arid and semi-arid regions.

Tilling strips in rye at Apple Valley land treatment site



Comparison of energy use (see EPA-430/9-75-003)

Now that land treatment has been placed on a firmer engineering basis, more systems of this type will undoubtedly be built in the future. By improving the design and operation processes of land treatment systems, the Corps' Land Treatment of Wastewater Program has made a substantial contribution in developing this waste treatment alternative.

Stabilization pond at Belding, Michigan, land treatment system

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