LAND TREATMENT OF WASTES IN GEORGIA: A LOOK TO THE FUTURE

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INTRODUCTION

In the last decade a number of wastewater land treatment systems have been designed and/or implemented in Georgia. Land treatment of municipal and industrial sludge in Georgia has increased dramatically in the past decade paralleling a national trend in which over 60% of all municipal sludge is land applied. Municipal sludge is primarily applied to agricultural crops, but forest land is frequently used for industrial sludge. Land treatment has become an acceptable alternative for treatment of wastewater and as emphasis on enhancing environmental protection and providing clean water increases, land treatment may be the only acceptable alternative to surface water discharge in many parts of the State. With a few exceptions, the dominant method of land treatment is spray irrigation and the trend is likely to continue. For most wastes, overland flow and rapid infiltration systems do not provide as high a degree of treatment as spray irrigation, are suitable only to a narrow range of site and management conditions, and often result in a point discharge resulting from collection ditches in overland flow systems and from subsurface drainage networks in rapid infiltration systems. Wetlands, either natural or constructed, offer only a limited opportunity for wastewater treatment and have a short usable life in comparison with terrestrial systems.

The majority of the spray irrigation systems implemented in Georgia have been on forest land, as contrasted with the rest of the country, which has seen implementation of primarily agricultural systems. Size of the systems in Georgia ranges from a few hectares (5 acres) to over 3500 hectares (8500 acres). With nearly 70% of the State in forest land and with forest being the dominant vegetation in the densely populated regions of the State, it is clear why forests have become the vegetation of preference for spray irrigation. Elsewhere in the U.S., forest systems have been most widely used in regions where supplemental irrigation of crops is not generally practiced, land slopes are steep, inexpensive land is readily available, intensive management is undesirable, and a non-food chain crop is preferred.

Land treatment by spray irrigation began in the early 1970's in Georgia as an alternative for small systems that did not have a suitable receiving stream for discharge. In 1973, a research and demonstration forest spray irrigation project was begun at the Unicoi State Park near Helen. The results of the research (Nutter, et al., 1978) provided the basis for development of Georgia Environmental Protection Division guidelines for design and operation of spray irrigation systems. The guidelines, in conjunction with publication by the U. S. Environmental Protection Agency of a revised design manual for spray irrigation in 1981 (U. S. Environmental Protection Agency, 1981) have provided the basis for evaluation, design and operation of spray irrigation systems in Georgia. The Unicoi system not only provided important research results, it also provided a site where regulators, designers and public officials could observe first hand the operation and visual appearance of a land treatment system.

Future use of spray irrigation in Georgia will likely center on forests in the mountain and piedmont regions and on crops in the coastal plain region. Forest land is more plentiful in the mountains and piedmont, and slopes that are often too steep for development may be suitable for spray irrigation. Use of forests for land treatment also preserves green space. Coastal plain land treatment will be dominated by crops as the principal vegetation because: 1) most forests occur in areas with a seasonal high water table and 2) there will be an increasing demand to find additional sources of water for crop irrigation.

Little attention has been focused on the potential of forests for treatment of wastewater except at a few research locations around the U.S., most notably Pennsylvania, Georgia, Michigan, and Washington. It is generally within these states that most forest systems are found today. Local demonstration and/or prototype systems appear to have been important in leading the way to acceptance and implementation of forest land treatment systems. In contrast, crop irrigation has received the most attention for use of wastewater as supplemental irrigation and a source of nutrients. The technology for optimal utilization of wastewater by crop irrigation is well established.

Forest irrigation, on the other hand, is practiced somewhat differently than crop irrigation. Forests do not need irrigation to supplement rainfall. To keep the land area requirement as small as possible, forests must be managed for different nutrient assimilation than crops because forest harvest occurs much less often. These disadvantages do not preclude the use of forests, there are a number of successful systems, particularly in Georgia (Nutter, 1986; Red and Nutter, 1986) and elsewhere (Sopper, 1986; Brockway, et al., 1986), that demonstrate how careful design and operation lead to adequate wastewater treatment, and protection of the environment and water quality.

Utilization of spray irrigation in the next decade and beyond will require an aggressive program of assistance to and education of designers and public and industrial officials and a reevaluation of the philosophy of locating and sizing publicly owned treatment works (POTW). Large tracts of land near metropolitan areas are becoming more scarce, and there are few locations with sufficient land to handle the flows from large regional POTW's. Dispersion of small-flow POTW's within a planning area will in many cases assure availability of land for spray irrigation. Communities can take an aggressive stance now by obtaining options on land for future use for land treatment. This practice will assure land availability for land treatment as the community grows and will provide green space at the same time. Keeping track of and regulating many small POTW's is more difficult than for a single large plant, but goals can be met with proper operator training and implementation of guidelines and regulations tuned to smaller systems.

Land treatment, coupled with an allowable winter or wet season surface water discharge in some river basins of the State when discharge is usually at its highest, could result in greater use of land treatment in situations where wet season land area requirements control design. In these situations, not all the wet season effluent production need be discharged to surface water, only the excess over the effluent flow accommodated by the required summer season land area.

To implement the anticipated growth in the use of land treatment, improved knowledge in several vital areas is needed to aid designers, regulators and other decision makers. The greatest need for knowledge is about design and operation of forest land treatment systems.

FUTURE ISSUES

A Conference held in 1983 (Page, et al., 1983) identified several areas in which additional knowledge was needed to improve the practice of land treatment. Many of the needs identified at the Conference were common to both forest and agricultural systems, such as public acceptance and health issues. A few areas of additional information about forest systems were identified to fill knowledge, design and operation gaps. Addressing the same issues in agricultural systems will not necessarily provide valid answers for application to forest systems.

A number of land treatment design, operation, and risk issues are unique to forests. Some of these are:

- land area requirement generally greater than agriculture due to lower nutrient uptake;
- presence of forest floor and soil organic matter improves potential for management of hydraulic loading and is important to the fate of pathogens, organics, and heavy metals;
- year-round operation is possible without risk of soil erosion;
- low level of management required;
- offers a flexibility in design and operation that permits easy modification to accommodate improved knowledge and/or site specific operational experience;
- frequent access for harvest and/or crop management not required; and
- outside human food chain.

The following general topics identify issues and or gaps in knowledge unique to forest systems. The topics are listed in order of relative importance, although all issues must be addressed at some time in the near future if the optimum utilization of forests (and crops to some extent) for land treatment is to be realized.

1. Design criteria
2. Risk assessment
3. Economic factors
4. Operational procedures
5. Public and regulatory acceptance
6. Design and operational guidelines.

Specific information developed for each of the above topics will advance the design and implementation of wastewater treatment by spray irrigation. As this information becomes available (some of which can be gained by better documentation of the performance of existing systems) the options for the designer will be improved. In the meantime, the designs must follow the relatively conservative path used thus far.

Design Criteria

Perhaps the greatest gap in development of adequate design criteria for forest systems is the lack of knowledge of nutrient cycles, particularly nitrogen. Nitrogen loading is often the critical design factor which controls land area requirements and vegetation selection and management. Because each forest ecosystem is unique, nutrient cycling information must be developed for each forest type. Unfortunately, nutrient cycling research in natural forest ecosystems is of little value to development of design criteria for wastewater application because the addition of water and nutrients markedly alters nutrient pathways in the normally nutrient-poor ecosystem.

The principal concern with nitrogen is maintenance of nitrate-nitrogen below the drinking water standard in groundwater. Thus, net nitrogen storage in the harvestable biomass, the role of understory vegetation in the annual uptake and storage cycle, and occurrence of and management of denitrification are important factors necessary to the development of site specific design criteria for nitrogen.

The production and utilization of total biomass, not just traditional forest products alone, must be considered to improve the efficiency of nutrient storage, reduce the land area requirement and increase revenues.

Forest systems generally have a greater hydraulic loading capacity than agricultural systems because of steeper slopes, the presence of the forest floor, less frequent equipment access, higher evapotranspiration losses, and good soil hydraulic properties. However, there does not currently exist adequate field design methodology for determining the hydraulic loading capacity.

Risk Assessment

Page, et al. (1983) identified risk assessment of land treatment systems as a high priority need. The fate of organics and heavy metals needs to be better defined for forest systems, particularly for certain types of industrial wastes. The importance of soil pH for metals retention is one area that needs further definition for forest systems.

The risk to wildlife living or transiting a forest land treatment system has been addressed in several studies, and the results have shown no adverse effect. As forest systems are implemented in different regions and ecosystems of the State, a survey of wildlife impacts is necessary to document the low risk associated with land treatment so that hunting, fishing and other recreational pursuits may proceed without public concern.

Recycling of water for reuse must be encouraged. Adequate documentation of existing recycling operations and to water quality is needed to gain public acceptance.

Economic Factors

Little information exists on the cost of irrigating forests over a range of conditions, since it is not as common a practice as in agriculture. Detailed analysis of existing forest irrigation systems and evaluation of alternatives will provide better information to the planner for development of cost-effective comparisons. Land treatment is frequently eliminated from consideration, either in comparison with conventional treatment or with other land treatment alternatives, because inadequate cost information is available.

Information about forest tree growth response and potential markets of the wood products are necessary to prepare adequate cost comparisons between alternative treatment systems as well as to select the optimum forest management scheme. The economics and suitability for wastewater treatment of other forest systems such as short rotation hardwoods for biomass and/or energy production must be considered. Quality of the wood and its intended use must also be considered.

Several land treatment systems employ recycling of water and/or other resources, and there exists a potential at many locations to incorporate recycling into the design. Improved understanding of the economics of recycling would likely result in greater application of land treatment technology.

Operational Procedures

Experience at a number of forest land treatment systems has indicated that improved procedures must be developed for installing an irrigation system with minimum site disturbance. Site disturbance is the limiting factor controlling start-up application of wastewater. The site cannot be fully utilized until complete rehabilitation occurs. Realistic time schedules must be developed for implementing application of wastewater following construction, recognizing that a construction rehabilitation period is necessary before the system can come on line.

An important consideration to the long-term operation of a forest land treatment system is harvesting of the biomass and removal of the stored nutrients. Harvesting must be followed by a regeneration scheme, and wastewater application must be reduced or discontinued during this critical period.

Too often designs have failed to incorporate adequate land area for use during harvesting and regeneration or have failed to consider the need to harvest the biomass at all. Harvesting and regeneration techniques that preserve the hydrologic and chemical assimilation attributes necessary to achieve successful treatment of the wastewater must be developed and tested.

Public and Regulatory Acceptance

Public acceptance of wastewater irrigation has greatly improved in the past decade. However, because of the lack of operating forest systems and/or the presence of demonstration systems, there tends to be a lower acceptance level of forest systems. Three principal issues must be addressed to gain improved public and regulatory agency perceptions of forest systems: public education, agency technical staff education, and improved communication between the research and design communities on the one hand and the public and agencies on the other. Public acceptance was an issue given high priority in the early 1970's and although gains have been made, it is still a high priority topic.

Design and Operational Guidelines

There is a continuing need for new information to be translated into working design and operational guidelines that regulatory agencies and the public can use to judge the worthiness of projects. After the technology is accepted, there must be an orderly means of incorporating the technology into existing or new guidelines and/or regulations.

Vital to proper implementation of the technology is development of guidelines for system operation and certification of trained operators.

CONCLUSIONS

Land treatment of municipal and industrial wastewater is a viable alternative to surface water discharge. It is predicted that the use of land treatment by spray irrigation in Georgia will increase in the next decade and that the dominant vegetation type will be forests in the mountain and piedmont regions and agricultural crops in the coastal plain region.

Utilization of spray irrigation in the next decade and beyond will require an aggressive program of assistance to and education of designers and public decision makers to assure adequate evaluation of alternatives and implementation of designs. Regulatory and funding policies must be developed to encourage construction of dispersed, small wastewater treatment plants because large tracts of land required for larger plants will not be available in the future. Combined year-round land treatment with surface water discharge during winter may be a viable alternative for protection of environmental quality, thereby permitting the use of land treatment at locations not otherwise thought possible.

Forests are expected to be the dominant vegetation type. Design and operation can be improved by clearer definition of six general issues, expressed as future needs to improve the state of knowledge and implementation of wastewater treatment: improved design criteria, assessment of risk, evaluation of economic factors, development of operational procedures, public and regulatory acceptance, and development of improved design and operational guidelines. The six issues can be divided into two general categories: 1) design and operation, and 2) public acceptance.

The principal issues that would provide the greatest step forward in improving our knowledge and implementation of land treatment systems are:

- improved understanding of the nitrogen cycle and estimates of net annual nitrogen storage in the biomass, enhancement and management of denitrification and procedures to manage the vegetation to maximize nitrogen assimilation;
- assessment of alternative forest vegetation systems (e.g., short rotation hardwoods) to minimize land area requirements and maximize biomass production without compromising wastewater treatment goals;
- improvement in installation and operation procedures for forest irrigation systems;
- development of forest management techniques, to include harvesting and regeneration procedures that recognize the unique features and goals of a forest land treatment system;
- improved understanding of the relative risks associated with forest wastewater applications of heavy metals and organics in comparison with other wastewater treatment and disposal alternatives;
- utilization of regional demonstration and prototype systems for designers, regulatory agencies, and the public to observe and use to improve communications.

Specification of the knowledge gaps and future needs is not to imply that systems designed today do not meet environmental goals or regulatory intent. Quite the contrary. Forest systems have been designed and are operated successfully as evidenced by a number of systems in Georgia and elsewhere. Expansion of the knowledge base will serve to fine-tune design and operation procedures as well as expand the base of potential forest land areas available for land treatment. It will also serve to aid in developing realistic economic comparisons with other vegetation systems and with other treatment alternatives.

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