Handbook of Land Treatment Systems for Industrial and Municipal Wastes

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Introduction to Land Application As a Treatment Concept

PURPOSE OF THE BOOK

It is the purpose of this book to present the criteria and procedures needed for the complete design of land treatment systems for municipal and industrial wastes. Prior to 1970 land treatment was seldom used by the engineering profession to solve waste treatment problems. In the decade 1970-80 the concept became reestablished in the spectrum of reliable technologies available for wastewater treatment. A considerable research effort has not only established the treatment capability and reliability of land treatment but has also shown that the capital and operating costs and energy usage can be significantly less than for the more familiar mechanical systems. Many of the standard engineering design textbooks still mention land treatment only in passing, if at all. This book is intended to fill that gap.

HISTORICAL BACKGROUND

Disposal of wastes to the land has been an accepted and recognized cultural practice since time began. Stabilization and assimilation of body wastes in the soil are complete, and problems do not occur with low-density, migratory populations of people or animals. The higher density conditions that can cause problems have been documented since biblical times (1), and these problems require a technology for management rather than random disposal. Application of wastes to the land emerged as a technology with the centralization of people in towns and cities. The earliest system documented in the literature was Bunzlau, Germany (2) where a sewage irrigation system was in operation for over 300 years, commencing in 1531. A system in the vicinity of Edinburgh, Scotland began operation around 1650 (2). The value of the wastewater as a fertilizer for vegetable and other crop production was well recognized.

LAND APPLICATION IN NORTH AMERICA

By the mid 19th century land application of wastes was considered to be the safest and most reliable method for waste disposal by the technical experts and regulatory officials of the time. The connection between contaminated water and disease was recognized, although the causative agents were not identified, so waste discharge to water supplies was avoided. The first comprehensive reviews of wastewater disposal in the U.S. were by George Rafter of the U.S. Geological Survey. In a series of reports (3)(4)(5) from 1894 to 1899 he reviewed the status of wastewater treatment in the U.S. and in Europe. Most of the 143 sewage treatment facilities in the U.S. and Canada as of 1899 (3) were land treatment systems (See Table 1-1). Rafter drew the following conclusions (direct quotations):

- The most efficient purification of sewage can be attained by its application to land.
- On properly managed sewage farms the utilization of sewage is not prejudicial to health.
- Sewage may be purified by broad irrigation at all seasons of the year at any place where the mean annual temperature

of the coldest month is not lower than about 20° to 25° F.

- From the experience gained abroad it is clear that we may successfully cultivate almost any of the ordinary agricultural productions of the United States on sewage farms, due regard being had in every case to the special conditions required for each particular crop.

- Sewage utilization should go hand in hand with purification. When operated with reference to all the necessary conditions, a proper degree of purification may be attained as well as satisfactory utilization.

- The proper method of utilizing sewage is, for purposes of irrigation, be means which do not differ, except in matters of detail, from those of ordinary irrigation as practiced abroad for centuries.

Table 1.1: Some Early Land Treatment Systems in the U.S.

Location	Date Started	Area (acres)
Boulder, CO	1890	–
Calumet City, MI	1888*	12
Woodland, CA	1889*	240
Fresno, CA	1891*	4,000
San Antonio, TX	1895	4,000
Vineland, NJ	1901*	14
Lubbock, TX	1915*	–
South Framingham, MA	1889	–

*System still in use.

Current Status

The use of land treatment began to decline soon after Rafter published these conclusions, and by the 1960's the concepts were almost forgotten. By the time discussion again began in the early 70's many of his conclusions were the subject of bitter debate and controversy. Jewell and Seabrook (2) traced the history of the development and the long, but temporary, decline. Among the factors identified for the decline were: pressures for alternative land uses, overloading due to incomplete technical understanding, and the development of the germ theory, with the use of chlorine as an effective disinfectant which made it "safe" to discharge partly treated sewage to waterways.

The focus shifted almost completely to "modern methods of sewage treatment" by the early 1920's, and design criteria for trickling filters, activated sludge, etc. were all available. A considerable effort has been expended in the past 50 years to improve the efficiency and understanding of these "modern methods" but the basic design criteria are still about the same as they were in the beginning. By the late 60's it was recognized that there was more to pollution than BOD and suspended solids and it was decided that a strong federal role and funds would be needed to clean up the nation's waterways. Federal legislation, commencing with the Clean Water Act of 1972 (PL 92-500) proposed a "zero discharge" concept and encouraged a reuse and recovery philosophy. Land application of wastewater is the only way to achieve all of those goals and the concept was reborn. It was not accepted at the time as a technology by much of the engineering profession and regulatory community. As a result, a very significant research and development effort was undertaken to reconfirm the conclusions that were so obvious to Rafter and to develop criteria for reliable and cost effective design, construction and operation. Table 1-2 demonstrates the recent increase in the number of land treatment systems.

Table 1.2: U.S. Municipalities Using Land Treatment

Year	Number of Systems
1940	340
1945	422
1957	461
1962	401
1968	512
1972	571
1981	1,180

In Rafter's time sewage treatment systems were typically found only at the larger, more sophisticated metropolitan centers that could not discharge to an ocean, and land treatment was the preferred method. Except in special circumstances it is unlikely that land treatment would be the preferred method of treatment for the very large metropolitan centers that exist today. The costs and the jurisdictional problems in developing a single very large system would be difficult to overcome. However, there are no technical constraints on the size of a system and, as will be shown in the remaining chapters of this book, land treatment can be a viable and cost effective choice for many industries, for small towns and moderately large cities and for portions of large metropolitan areas.

The design approach for land treatment systems is essentially empirical; that is, observation of successful performance followed by derivation of criteria and mathematical expressions that describe overall performance. Criteria for all of the wastewater treatment processes in use today were developed this way. Use of the criteria in this book should produce reliable, cost-effective, and conservative designs for municipal and industrial wastes.

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2

Basic Technology and Design Approach

CONCEPTS

Land treatment is defined as the controlled application of wastes onto the land surface to achieve a specified degree of treatment through natural physical, chemical, and biological processes within the plant-soil-water matrix. The basic wastewater concepts include: Slow Rate (SR), Rapid Infiltration (RI) and Overland Flow (OF). The titles were adopted to reflect the rate of water movement and the flow path within the process. In some earlier texts the term "irrigation" was often used to describe the slow rate process. The present term was chosen to focus attention on wastewater treatment rather than on irrigation of crops. In addition to these basic wastewater processes there are criteria presented in later chapters for combination systems, wetlands and other innovative technologies, large scale septic tank/soil systems, and land application of sludge.

Site Characteristics

The desirable site characteristics for the three wastewater processes are given in Table 2-1. These are not limits to be adhered to rigorously, but rather typical ranges based on successful experience.