

National Environmental Health Association

---

# **Onsite Wastewater Disposal**

**Richard J. Perkins**

**National Environmental Health Association**

---

# **Onsite Wastewater Disposal**

**Richard J. Perkins**



**LEWIS PUBLISHERS**

## Library of Congress Cataloging-in-Publication Data

Perkins, Richard J.

Onsite wastewater disposal / Richard J. Perkins.

p. cm.

Bibliography: p.

Includes index.

1. Sewage disposal, Rural--United States. 2. Sanitation, Rural--United States. 3. Sanitation, Household--United States.
4. Septic tanks--United States. I. Title.

TD523.A1P47 1989 89-2534

628.3'62--dc19

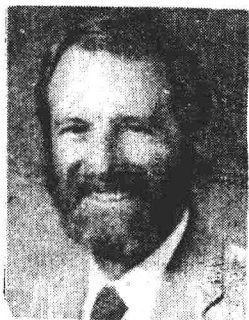
ISBN 0-87371-211-0

COPYRIGHT © 1989 by LEWIS PUBLISHERS, INC.  
ALL RIGHTS RESERVED

Neither this book nor any part may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, microfilming, and recording, or by any information storage and retrieval system, without permission in writing from the publisher.

LEWIS PUBLISHERS, INC.  
121 South Main Street, Chelsea, Michigan 48118

PRINTED IN THE UNITED STATES OF AMERICA



**Richard J. Perkins** is a Water Resources Specialist with the New Mexico State Environmental Improvement Division in Santa Fe. Dr. Perkins received his PhD in Ecology from the University of Georgia in 1971. He also holds a BA in Biology from the University of California and an MS in Zoology from the University of Georgia. In 1972, Dr. Perkins joined the faculty of the University of Kansas, where he taught courses on ecology and environmental quality, was instrumental in the development of an environmental studies major program, and became chair of that program.

In 1978, he moved to New Mexico and began working to increase the effectiveness of that state's septic tank control program. Dr. Perkins worked with septic tank installers in developing and implementing environmentally protective system designs for use in areas not suitable for standard systems, and developed a number of guidance manuals along with a training program for installers and enforcement personnel. He has initiated research on the effects of septic tanks on ground water and has published on that topic. Since 1984, he has expanded his interests and activities to include development of a broader range of ground water quality protection policies and programs.

## Acknowledgments

I would like to thank engineers Duff, Rosenberger, Fagan, Breese, and McGuiness for developing materials which have enhanced the substance of this book.

## Preface

About one in every four new houses being constructed makes use of an onsite septic system to treat and dispose of household wastewater. Too many of these systems do not do the job they are built to do. Failure takes the form of unpleasant and health-threatening sewage on the surface of the ground. It takes the form of sewage backing up into the plumbing fixtures inside the house. It takes the form of polluting the ground water destined to enter someone's well.

Failed onsite household wastewater disposal systems are becoming an increasing problem over much of the country as homes are constructed in rural areas unsuitable for conventional onsite systems. Two-thirds of the nation's land area is unsuitable for septic system installation and use. The septic tank installer who constructs a septic system inadequate for these sites may be asking for a critical review of his contractor's license. The homeowner who puts in an expensive but "environmentally responsible" system may be throwing money down the drain. The land developer who sells lots in these areas without providing a warning to consumers may spend some time in court. The governmental regulator who approves inadequate systems may spend some unpleasant time in his or her supervisor's office. The information herein is presented to prevent these sorts of problems as well as to expand the land area which can be safely developed through the use of modern septic system technology.

Even the most experienced installer of septic systems may not be able to put in a functional system which is significantly different in form and substance from those he has been installing all his life, particularly if he is provided only an explanation of the theories underlying the new technology. Installers must consider siting, design, construction, installation, operation, and maintenance. This

book provides easy-to-understand methods of proper septic system practices suited to a broad range of site conditions, and the reasons for using them. Potential problems, both with the system components and the people who regulate septic systems, are described and potential solutions provided.

# Contents

## Chapter

1	Introduction	1
<b>PART I: AN OVERVIEW OF ONSITE WASTEWATER DISPOSAL</b>		
2	Regulations and Processes	7
	Codes and Regulations	7
	The Treatment Process	8
	The Disposal Process	11
3	Selection of Site and System	15
	Site Evaluation	15
	System Selection	33
	System Location	38
<b>PART II: SYSTEM DESIGN, CONSTRUCTION, AND MAINTENANCE</b>		
4	Waste Process	43
	Septic Tanks	43
	Dosing Chambers	53
5	Conventional Waste Disposal Systems	65
	Conventional Drain Fields	65
	Deep Absorption Trenches	82
	Seepage Pits	85
	Cesspools	93
	Absorption Beds	94
	Leaching Chambers	96
6	Modifications of Conventional Systems	99
	Alternating Drain Fields	99



Elevated Drain Fields	102
Sand Mounds	104
Land Application	133
Sand Filters	154
7 Low-Impact Systems	175
Evapotranspiration	175
Holding Tanks	193
Composting Toilets	196
Grey Water Systems	203
Disinfection	210
 PART III: SYSTEM SUPPORT	
8 Solving Problems	221
Toilet Won't Flush	221
Liquid Poned Over Drain Field	223
Siting and System Problems	225
Infiltration Problems	226
9 Water Conservation	229
Leaks	229
Retrofits	230
Behavior	232
Appliances	233
10 Lot Evaluation	235
 Appendix: Formulas	 237
 Bibliography	 239
 Index	 249

## List of Figures

2.1	Typical septic tanks	9
2.2	Typical aerobic treatment unit	11
2.3	Drain field under construction	13
3.1	Typical plot plan	16
3.2	Determining number of people in household	17
3.3	Moist sand cast	19
3.4	Dry loam cast	20
3.5	Ribbon of moist loam	21
3.6	Clay ribbon	22
3.7	Soil texture triangle	23
3.8	Root depth and soil drainage capacity	24
3.9	Soil peds	25
3.10	Aggregated blocks of clay	25
3.11	Clod of sandy loam	26
3.12	Movement of water by capillarity	27
3.13	Percolation test water supply	29
3.14	Measuring drop in water level	30
3.15	Determining soil conditions	33
3.16	Measuring ground slope	34
3.17	"Stacked" pipes	38
4.1	Typical septic tank design	45
4.2	Gas baffles	47
4.3	Risers	50
4.4	Measuring the scum layer	51
4.5	Measuring the sludge depth	52
4.6	Typical dosing chamber	54
4.7	Automatic dosing siphon	54
4.8	Typical pump curve	62
5.1	Digging an absorption trench	66
5.2	Cross section of an absorption trench	68

5.3	Gravel voids filled with dirt	72
5.4	Installing filter fabric	73
5.5	Distribution pipe configurations	73
5.6	Distribution box	74
5.7	Drop boxes	75
5.8	Measuring the slope of the trench bottom with a carpenter's level	77
5.9	Measuring the slope of the trench bottom with an "Arkansas" level	77
5.10	Backhoe bucket with side teeth to rough up sides of trench	78
5.11	Cemented gravel	80
5.12	Clay pipe joints	80
5.13	Deep trench	82
5.14	Seepage pit	86
5.15	Seepage pit liner construction	91
5.16	Seepage pit outlet pipe	92
5.17	Looped distribution system in a seepage bed	95
5.18	Leaching chamber	96
6.1	Alternating fields	100
6.2	Diversion box	101
6.3	Elevated drain field	102
6.4	Elevated drain field on a slope	103
6.5	Sand mound system components	105
6.6	Cross section of a mound	106
6.7	Available absorption areas on flat and sloping ground	111
6.8	Example mound design	114
6.9	Example mound design	124
6.10	Example distribution system design	126
6.11	Laterals located below manifold	131
6.12	Lateral extension for access	132
6.13	Flood irrigation system	136
6.14	Sprinkle irrigation system	140
6.15	Trickle irrigation system and emitter	141
6.16	Shallow subsurface irrigation system	142
6.17	Low pressure system loading rates	143
6.18	Shallow subsurface plot and distribution system	145
6.19	Cross section of a shallow subsurface trench	147
6.20	Tamped earth dams	152
6.21	Elevated sand filter	155

6.22	Uncollected sand filter trench	157
6.23	Sand filter in highly permeable soil	158
6.24	Effective size and uniformity of sand	159
6.25	Collected subsurface sand filter	161
6.26	Intermittent sand filter	163
6.27	Recirculating sand filter	164
6.28	Proportional flow controls	165
7.1	Evapotranspiration system	176
7.2	United States evaporation rates	177
7.3	Effects of plants on evaporation rates	181
7.4	Change in water levels in ET bed	184
7.5	Polyethylene sheeting joints	189
7.6	Pipe penetration of liner	190
7.7	ET distribution system	191
7.8	Distribution system cross section	191
7.9	Large volume composting toilet	198
7.10	Small volume composting toilet	200
7.11	Grey water system components	203
7.12	Separate grey water tank	206
7.13	Simple sand filters	209
7.14	Cartridge filtration	209
7.15	Disinfection unit	211
7.16	Contact chamber	214
8.1	Troubleshooting	222
9.1	Flush toilet	231

## List of Tables

2.1	Comparison of typical septic tank and aerobic unit effluents	10
3.1	Soil classification	19
3.2	Example percolation rate calculation	30
3.3	Relationship between soil type and percolation rate	31
3.4	Site conditions and alternative systems	35
4.1	Recommended septic tank capacities	44
4.2	Septic tank inside dimensions	45
4.3	Commonly required liquid waste system setback distances	49
4.4	Head loss due to friction in PVC pipe	60
5.1	Square feet of trench bottom area required by the <i>Uniform Plumbing Code</i>	69
5.2	Square feet of bottom area recommended by the <i>Manual of Septic Tank Practice</i>	69
5.3	Square feet of bottom area recommended by the Environmental Protection Agency	70
5.4	Absorption areas for seepage pits	88
6.1	Recommended mound interior absorption system configurations	107
6.2	Application rates for various mound fills	108
6.3	Natural soil infiltration rates	110
6.4	Correction factors for natural ground slope	116
6.5	Flow rates through holes of various diameters	119
6.6	Recommended lateral distribution pipe diameters	120
6.7	Irrigation efficiencies for various soils	138
6.8	Loading rates for elevated sand filters	162
7.1	ET water budget	182

7.2	ETA system loading capacities	186
7.3	Wastewater characteristics	194
7.4	Water volumes associated with grey water systems	208
9.1	Residential water use by activity	231

## Introduction

In nature, all living things use resources and produce wastes. The wastes of each group of organisms represent resources for another group of organisms, so that materials are recycled and reassimilated. We are now learning that our health is totally dependent on the health of the environment and its cycles, that accumulations of wastes can cause severe environmental pollution, and that wastes should be recycled whenever possible.

It used to be said that a stream would cleanse itself in 10 miles of flow. This distance generally was maintained between settlements along rivers so that the waste from an upstream settlement would not be consumed by those downstream. But, as population densities grew, the capacity of rivers and streams to assimilate the wastes and cleanse the water was exceeded, resulting in the accumulation of wastes in a deteriorating environment. Now communities using rivers and streams for water supplies must treat the water extensively because chances are that some proportion of the flow entered the water channel as waste discharged from an upstream community.

In many areas of the country, septic wastes from rural onsite liquid waste disposal systems constitute a major source of ground water recharge. Septic tanks and cesspools rank highest among all wastewater systems in total volume of wastewater discharged directly to ground water (more than a trillion gallons per year) and are the most frequently reported sources of fecal bacteria and toxic chemical contamination. It is said that a few feet of soil between the disposal excavation and the ground water table are sufficient to cleanse the sewage effluent. However, the cumulative effects of inadequately treated sewage on local and regional ground water quality are potentially much more serious than the effects of surface water pollution. The goal of proper onsite liquid waste disposal practices is both to prevent disease and to provide future genera-

tions with ground water that can be used without extensive and expensive treatment.

Periodic publications such as the *Journal of the American Water Works Association* and the *Journal of Environmental Health* have described a number of disease incidents associated with onsite waste disposal systems. In Richmond Heights, Florida, a church and day-care center septic tank contaminated a drinking water well 150 ft away. Twelve hundred people contracted gastroenteritis. In Polk County, Arkansas, the well of a general store became contaminated by septic tank effluent. Ice made from the well water transmitted viral hepatitis. In Yakima, Washington, typhoid fever was spread by wells contaminated by the septic system of a typhoid carrier. There are other instances throughout Europe and America where long-term biological and chemical contamination of ground water has resulted from onsite wastewater disposal.

People tend to dispose of their wastes into their neighbor's drinking water supply, whether surface or subsurface. Since the dilution factor is often relatively small for discharges into surface waters—some streams consist *only* of sewage—surface water supplies require expensive treatment. In terms of numbers of systems supplying water, wells are the most common and to date, very few water supplies from wells need treatment to make the water safe to drink. Prevention of contamination is much less expensive than paying to remove contaminants, particularly when treatment must be done by the homeowner instead of the community as a whole.

For many years, it was assumed that connection to public sewers should be the goal of every household. Only recently have the federal government and a few engineers, city councils, and county commissioners come to the realization that in many areas, onsite disposal is far more cost-effective than a collection system and a central treatment unit. Many of the sophisticated treatment plants built in rural communities have posed significant problems to those communities that could not afford the maintenance costs, paying skilled operators to manage the facilities, or paying the pollution fines resulting from improperly operated facilities.

Onsite disposal is a viable alternative to sewerage. It often provides a greater degree of protection to public and environmental health than a public facility, and at far less expense to the homeowner and the taxpayer. Given the fact that nonmetropolitan areas have been growing faster than cities, the future will bring an increasing concern for the health and environmental effects of on-



site sewage disposal, as well as an increasing emphasis on the proper design, installation, operation, and maintenance of these on-site systems.

Onsite disposal systems can provide adequate ground and surface water protection for present and future generations, or they can make water totally unfit for consumption. Proper design, location, installation, and maintenance make the difference between these two scenarios. The one-half million new onsite systems being built each year have significant potential to impact ground water quality over large areas of the country. Many of these systems will be installed in areas of scenic beauty, suburban tranquillity, and environmental vulnerability. Where homesites are not amenable to standard onsite disposal practices, the protection of human health and environmental quality demands the use of systems designed to overcome particular limitations of the site. Areas of high flooding potential, steep slopes, thin topsoil, high ground water tables, and clay soils can present problems which, if not solved by design, can result in angry neighbors, paranoid public health officials, and resentful grandchildren.

The technology of onsite liquid waste disposal has rapidly advanced during the last decade. In addition to the rediscovery of very old and very satisfactory methods of disposal, new methods have been developed for application on difficult sites. These new methods have been in use long enough that some performance data are available. It is now possible to present design criteria, construction methods, and maintenance requirements, as well as to identify potential problems for each of these systems. The designs presented in Part II of this book are tested and proven, are addressed by many states in their regulations, and are suitable for use both by persons living an isolated existence far removed from neighbors and by developers planning waste disposal systems for subdivisions. However, each site has its own climatic and physical characteristics, each installer has his own techniques, and each user has his own habits. None of these designs can be guaranteed to function properly under all conditions. On the other hand, the designs are proven as presented, and any change in design to conform to local conditions should be made with a clear understanding of the effect of that change.

The purpose of this book is to provide information sufficient to allow a homeowner, potential homeowner, contractor, septic system installer, or consulting engineer to evaluate the future site of a