LANDFILL LEACHATE RECIRCULATION SYSTEMS:

MATHEMATICAL MODELING AND VALIDATION

by

Philip T. McCreanor
B.S. University of Miami, 1990
M.S. University of Central Florida, 1994

A dissertation in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the Department of Civil and Environmental Engineering
in the College of Engineering
at the University of Central Florida
Orlando, Florida

Spring Term
1998

Major Professor: Debra R. Reinhart

Abstract

Bioenhanced operation of municipal solid waste (MSW) landfills can accelerate the stabilization of the organic fraction of the waste. Such enhancement promotes biogas energy production while reducing the potential for long-term adverse environmental impacts. Bioenhancement has also been considered as a source reduction technique at problematic landfills. Bioenhancement primarily involves moisture control using leachate recirculation through the landfill, but also may include nutrient and buffer addition, aerobic decomposition within the landfill for temperature control, and MSW composition control.

Because leachate recirculation has been found to be the most practical approach to moisture content control, full-scale bioenhancement efforts tend to focus on this technique. Proper design and operation of the leachate recirculating landfill requires a more in-depth understanding of the hydraulics of leachate transport within the landfill than is presently available. Consequently, the objectives of the study were to evaluate the effect of leachate recirculation on the moisture saturation levels of the waste in the landfill, determine the area influenced by different recirculation methodologies, and to develop a design strategy. A modified form of SUTRA (Saturated-Unsaturated Transport), a United States Geological Survey (USGS) unsaturated flow and solute transport program was used to meet these objectives. Two of the most common types of leachate recirculation methodologies (trench infiltration and vertical wells) were modeled. The variables evaluated included leachate input rates, frequency of operation

of the recirculation system, the permeability of intermediate cover materials, permeability of the waste, and heterogeneity effects. Modeling results indicated that lateral spreading increased with decreasing permeabilities and increasing application rates, However, as permeability decreased, the upward movement of leachate increased which could result in surface seep problems. Waste mass anisotropies may result in an increase in lateral spreading and thus the impact area but may also cause side seep problems. The study of waste mass heterogeneities indicated preferential flow through high permeability areas and around low permeability materials but did not significantly affect lateral movement. The use of low permeability daily cover materials may significantly impede leachate movement. Therefore, low permeability materials should be avoided or breached prior to the placement of the next waste layer.

In addition to studying hypothetical leachate recirculation scenarios, four leachate recirculation field studies were modeled; the Mill Seat Landfill, Monroe County, New York, the Delaware Solid Waste Authority's Leachate Recirculation Test Cells, the Yolo County Landfill Demonstration Project, and the University of Central Florida - Environmental Protection Agency (UCF/EPA) Test Cell. Predicted leachate production was compared to measured values. This effort at model verification indicated channeled flow is a major leachate movement mechanism which must be studied and accounted for in future models. Results also indicated that increased data collection efforts are imperative to develop and applying models to full-scale operations.

ACKNOWLEDGMENTS

I would like to thank my committee members, Dr. Manoj Chopra, Dr. J. Paul Hartman, Dr. Ola Nnadi, and Dr. Bhimsen Shivamoggi, for taking time from their busy schedules to review and critique my work.

Dr. Debra R. Reinhart will always have my deepest gratitude for guiding me on my doctoral journey. She provided immeasurable guidance and support. In addition, she opened innumerable doors to me which enabled me to grow both personally and professionally. I find my self completing my doctorate with not just research skills but also teaching credentials, grant and proposal writing experience, and presentation skills thanks solely to her. Words truly cannot express how much she has contributed to my development in the past years.

To my colorful family I must express my love. Despite our geographic separation and differences in lifestyles, we have remained intimate friends and sources of support to one another. I can only hope that we continue to grow closer.

The greatest blessing in my life is that my close friends are too numerous to thank individually here. You are all truly the treasure in my life. Thank you.

TABLE OF CONTENTS

LIST OF TABLES

initial saturation) for the Yolo County Project.

LIST OF FIGURES