Long Term Planning For Integrated Solid Waste Management under Uncertainty

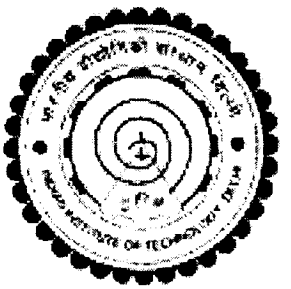
By

Amitabh Kumar Srivastava
Department of Civil Engineering

Submitted
In fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

to the



Indian Institute of Technology Delhi
New Delhi – 110016, India

July 2007

1. Solid waste management

CERTIFICATE

This is to certify that the thesis entitled "Long Term Planning for Integrated Solid Waste Management System under Uncertainty", being submitted by Mr. Amitabh Kumar Srivastava, to the Indian Institute of Technology Delhi for the award of 'Doctor of Philosophy' in Civil Engineering is a record of the bonafied research work carried out by him under my supervision and guidance. He has fulfilled the requirements for the submission of this thesis, which to the best of my knowledge has reached the requisite standard.

The material contained in the thesis has not been submitted in part or full to any other university or institute for the award of any degree or diploma.

July 2007

(Arvind K. Nema)
Civil Engineering Department
Indian Institute of Technology Delhi
New Delhi – 110016, India

Dedicated
To
My Parents

ACKNOWLEDGEMENTS

I would like to express my first sincere appreciation to my supervisor, Dr. Arvind K Nema for his excellent and inestimable guidance, which led to the successful completion of this dissertation. He has not only been supervising me but showing his profound knowledge and precise working philosophy, which would be an invaluable asset for my whole life.

I would like to express my gratitude to Prof A. K. Gosai, Dr Ravi Shanker and Dr A. K. Mittal for providing me valuable suggestions and remark as member of research committee. The help and encouragement provided by Prof. K.G. Sharma (Ex. Head, Civil Engineering) and Prof. A.K. Nagpal (Present Head, Civil Engineering) is also appreciable. I am also thankful to Prof. Mukesh Khare, Dr B.J. Alappat and Dr. G.V Ramana for their keen interest in my work and for providing great suggestions. I also thank the European Union funded Protea project and its project investigator Prof Manoj Datta for providing me opportunity to attend the training workshops at european universities.

I am thankful to Ministry of Human Resources Development, Government of India, and All India Council of Technical Education (AICTE) for sponsoring me under quality improvement programme (QIP) for this study. The support provided by the QIP coordinator, IIT Delhi and QIP staff during my stay and pre Ph.D. visit is also appreciable.

I am thankful to Prof. R C Saraswat (ex Director, BIET Jhansi) for granting leave and encouraging me for this study. I am also thankful to present director of BIET Jhansi Prof S.K. Awasthi for his support in completing this work. I am also grateful to my seniors and colleagues Prof A K Sachan, Dr A K Nigam, Dr. Mukesh Shukla Dr. Vikram Singh and Dr. Umesh Maheshwari for their encouragement and support.

I am also thankful to my friends Poonam Alhuwalia, Suresh, Anju, Priyanka, Vijya, Pravin, Santosh Kolte, Gouatm Pothal, Nitin Chaphalkar, R.K. Prasad and D L Parmar for providing me assistance from time to time. I am extremely thankful to Mr. Anurag Kandya for dedicating some of his time in checking of this manuscript. The supports from laboratory staff especially Mr. Sanjay, Mr. Iswhar Singh, Mr. Rajiv Mr. S.S. Shukla , Mr. Jaibeer and civil engineering department's staff Mr.Bikram, Mr. Rajveer Agwarwal and Mr. Mallii Ram are also appreciable.

I want express my indebtness to my parents, sisters and brother for their endless love and encouragement throughout my life. Finally my deep appreciations go to my wife Shalini and my son Kartikeya for their sacrifice and tremendous understanding over this duration.

I am also thankful to the anonymous reviewer whose comments have made significant improvement in the study.

A. K. Srivastava

Amitabh Kumar Srivastava

ABSTRACT

Solid waste management is increasingly becoming a challenging task for the municipal authorities due to increasing waste quantities, changing waste composition, decreasing land availability for waste disposal sites and increasing awareness about the environmental risk associated with the waste management facilities.

The present study focuses on the optimum selection of the treatment and disposal facilities, their capacity planning and waste allocation under uncertainty associated with the long-term planning for solid waste management. The fuzzy parametric programming model is based on a multi-objective, multi- period system for integrated planning for solid waste management. The model dynamically locates the facilities and allocates the waste considering fuzzy waste quantity and capacity of waste management facility. The model addresses uncertainty in waste quantity as well as uncertainties in the operating capacities of waste management facilities simultaneously.

An example problem has been presented to demonstrate the usefulness of the proposed methodology and the model in making the planning decisions related to solid waste management and achieving a robust and optimum plan. The model is solved at different levels of membership function, for the alternative solutions with respect to different objectives. It was observed that uncertainty in waste quantity is likely to affect the planning for waste treatment/ disposal facilities more as compared with the uncertainty in the capacities of the waste management facilities. The relationship between increase in waste quantity and increase in the total cost/ risk

involved in waste management is found to be nonlinear. Therefore, it is possible that a marginal change in waste quantity could increase the total cost/ risk substantially.

The information obtained from the analysis of modeling results can be effectively used for understanding the effect of changing the priorities and objectives of planning decisions on facility selections and waste diversions. The fuzzy multi-period planning for solid waste management is especially relevant in case of rapidly growing urban centers of developing countries due to great possibility of fluctuating parameters. As demonstrated using the example problem, the multi-objective, multi-period planning model can be a very helpful tool for the decision makers especially for addressing location-allocation problem of waste disposal facilities with fluctuating parameters.

Keywords: Solid Waste Management, Integrated solid waste management system, Long term planning, Multi-objective and Multi-period planning, Fuzzy parametric programming

LIST OF CONTENTS