MODELING TRANSPORT OF DISSOLVED ORGANIC (BIODEGRADABLE) PORTION OF MSW LANDFILL LEACHATE THROUGH UNSATURATED SOIL (VADOSE ZONE)

by

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Submitted

in fulfillment of the requirements of the degree of Doctor of Philosophy

to the

INDIAN INSTITUTE OF TECHNOLOGY DELHI

NEW DELHI-110016

MARCH, 2012

Certificate

This is to certify that the thesis entitled "Modeling transport of dissolved organic (biodegradable) portion of MSW landfill leachate through unsaturated soil (vadose zone)" is being submitted by Ms. Shukla Pal to Indian Institute of Technology, Delhi for the award of the degree of Doctor of Philosophy. The thesis has been prepared under our supervision and guidance in conformity with the rules and regulations of Indian Institute of Technology, Delhi and is a record of the original bonafide research work. The results presented in this thesis have not been submitted in part or full to any other universities or institutes for the award of any other degree or diploma.

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Acknowledgements

I want to express my sincere thanks to the faculty and staff of Chemical Engineering Department of I.I.T Delhi for their help and cooperation.

I sincerely thank Prof. S.K. Gupta, Department of Chemical engineering and Prof. T. R. Sreekrishnan, Department of Biochemical Engineering and Biotechnology, my supervisors, who consistently helped me to conduct my work and write my thesis. Without their encouragement I could not have surmounted the enormous difficulty that I faced as a part-time student and mother of two little children.

I want to thank Dr. Anil K. Saroha, Dr. K.K. Pant and Dr. Ratan Mohan for allowing me to use their laboratory facilities. I thank Dr. Rajesh Khanna for helping me to debug various computer codes and to run them.

I also sincerely thank Dr. S. S. Maitra, School of Biotechnology, JNU and his students for helping me to conduct biodegradation experiments.

I am also thankful to Er. P.K. Jain and his staff of J.N.U for cutting and excavating the undisturbed soil columns with which I conducted my experiments. I also thank the engineers of RITES to allow me to conduct my column experiments in their make-shift laboratory shed.

Last but not the least, I express my sincere thanks to my organization National Productivity Council (NPC) and my colleagues in NPC for their cooperation and moral support.

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ABSTRACT

An increasing concern of groundwater contamination due to unscientific disposal of municipal solid waste (MSW) has been the basis of this study. However, it has been reported in past that a number of natural attenuation processes, including anaerobic bio-degradation, take place in soil, which reduce the chances of ground water contamination. Therefore, understanding the mode and mechanism of transport of contaminant from MSW leachate through the vadose zone becomes important. In this study, we have developed a model considering physical non equilibrium conditions which is true for unsaturated zone. Further we have coupled Richard's equation with the solute transport model to predict the realistic transport process of contaminant in unsaturated soil zone. We have further carried out experiments on a realistic long (1.3 meters) undisturbed soil column to determine the transport parameters unlike most of the previous researchers who have carried out their experiments on laboratory scale chromatographic columns with disturbed soil. Pulse input and step input experiments were carried with a tracer dye (Brilliant blue FCF) in the undisturbed soil column. Batch adsorption experiments were carried out with the tracer dye as well as MSW leachate to establish the adsorption isotherms. Porosity measurement experiments were carried out on short undisturbed soil columns. Soil and MSW leachate were characterized before using in the experiments. Based on particle size distribution, the soil was classified as sandy loam. Anaerobic biodegradation experiment with actual MSW leachate has been carried out to elucidate the kinetics and evolve appropriate anaerobic model which has been substituted into the contaminant transport model as the sink term. The transport parameters were estimated as dispersion coefficient =0.11 cm^2/day; mass transfer coefficient=0.18 per day; adsorption coefficient =0.00022 cc/g and effective porosity=0.115. Biodegradation kinetic has been defined as a function of

time. Soil properties were taken from literature corresponding to sandy loam soil. The proposed transport model has been simulated with these parameters. Simulation study shows that organic contaminant could be degraded before the aquifer is reached. Further, sensitivity analysis has been carried out by varying different parameters. It is observed that the transport of organic contaminant from MSW leachate depends on velocity, mass transfer coefficient, biodegradation rate and most importantly, on soil properties. Therefore, in order to assess the impact of MSW landfill on groundwater, it is important to estimate these parameters appropriately. Further, case studies have been considered where leachate characteristic, soil characteristic, landfill details, depth to groundwater table is available. Simulations of leachate transport in these sites are found to be following the trend with respect to observed values.

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