MODELLING SETTLEMENT OF MUNICIPAL SOLID WASTE LANDFILLS DUE TO BIODEGRADATION

by

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1. Solid waste landfills

CERTIFICATE

This is to certify that the thesis entitled **"Modelling Settlement of Municipal Solid Waste Landfills due to Biodegradation"** being submitted by **Mr. Sumedha Chakma** to the ***Indian Institute of Technology Delhi*** for the award of the degree of ***Doctor of Philosophy*** is a bonafide record of research work carried out by him under my guidance and supervision. The thesis work in my opinion, has reached the requisite standard, fulfilling the requirements for the said degree.

The results contained in this thesis have not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.

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Abstract

Settlement of refuse in landfills is an important parameter that affects the design and long term stability of landfills. Settlement in landfills takes place due to primary and secondary compression of refuse. Mechanical compression and biodegradation of waste cause secondary compression in landfills. It is difficult to predict settlement in landfills since the refuse is not homogeneous; moreover, factors such as density, moisture content, temperature and pH of the refuse have a predominant effect on settlement. It has been observed that primary compression takes place during the construction period whereas the mechanical compression occurs post construction of the landfills. Further, settlement due to biodegradation continues on for a long duration of time depending on the availability of moisture, biodegradable matter and optimum conditions for reactions.

In this study, settlement of landfill is computed first to determine the primary compression of the refuse due to the overlaying layers for each fill during the construction stage. It is assumed that the refuse has both a constant and variable density in the model. Later, mechanical compression of the entire fill that occurs post capping of the landfills is evaluated considering the changes in the total stress for each layer.

A sensitivity analysis is further conducted to see the impact of the changes in the coefficient of compression that is used to compute primary and mechanical settlement in models available in literature. It is also observed that even a slight change in the values of coefficient of compressibility gives rise to a considerable change in the settlement rate.

Moreover, the settlement computed assuming a constant density of refuse yields a smaller value of settlement of the fill compared to the case where the density is assumed to be varying spatially and temporally. Furthermore, the variation in moisture content is modeled using the Richards Equation for the unsaturated landfill. The moisture content available at every node and at any instant of time is utilized in the biodegradation of the refuse, and the total amount of moisture required is computed by stoichiometry for the typical municipal solid waste comprising carbohydrates, proteins and fats. This quantity of moisture is further used as a source/sink term in the Richard's equation to compute the spatial and temporal variation of moisture content in the landfill. Factors like temperature and pH are also incorporated in the model.

In addition to this, the total amount of gas (predominantly methane and carbon dioxide) produced during biodegradation is also computed. It is assumed in the study that gases produced in the landfill during the biodegradation process escape instantaneously through the vents provided in landfills, which inturn results into a change in volume of the fill due to biodegradation. The settlement due to biodegradation computed in this study is compared with the settlement from the existing models.

A sensitivity analysis is also carried out to see the effect of pH, temperature and moisture content on settlement due to biodegradation. It is observed that the impact of imprecision and uncertainty of pH and temperature on settlement is not as profound as changes in other parameters in the existing models. The total settlement comprising mechanical compression and biodegradation is computed and compared with the available field data.

A good match between the two indicates that the biodegradation model could predict long term settlements in landfills adequately.

In addition to this, the total amount of gas produced during biodegradation at a particular site is computed through stoichiometry to compare it with an existing model. The difference in the results could be attributed to the non inclusion of important factors like pH and temperature in the existing model.

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