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Research Article

Landfill Leachate Management Using Modelling

Kamde Shivanand[1]*, Ghosh PK[2] and Gupta MK[3]

[1]Research Scholar, Bhilai Institute of Technology, Durg, Chhattisgarh, India

[2]Principal, Krishna Engineering College, Bhilai, Chhattisgarh, India

[3]Professor and Head, Department of Civil Engineering, Bhilai Institute of Technology, Durg, Chhattisgarh, India

***Corresponding Author:** Kamde Shivanand, Research Scholar, Bhilai Institute of Technology, Durg, Chhattisgarh, India.

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Abstract

Most landfills are unengineered in the country; therefore it is difficult to manage municipal solid waste, with respect to collection, transportation, disposal, composting and leachate treatment. This paper attempted to focus on various leachate modelling being used in leachate management to control over various characteristics found in leachate generated. Some important models, studied here are HELP model, LPI, water Balance model (wBm), Deterministic Multiple Linear Reservoir model (DMLRm), Stochastic Multiple Linear Reservoir model (SMLRm), Leachate Generate (LG) prototype model. In this paper experimental analytical and mathematic model have also been considered. Most of the models performed under certain conditions and bounded to limits. The results of modelling studies showed that they provided specific value of specific parameters which is not viable. A prototype leachate generated model which is based on layer theory, using Gomutra as a simulator was found to be effective, economic, ease to manage. The results revealed that the effects of Gomutra to control pH value, temperature, moisture content ratio of BOD/COD, C/N ratio and other minerals was found to be positive; which would helpful to prevent contamination of surface water and enhances, soil conditions growth of plants successfully.

Keywords: MSW; Leachate Generated (LG); Leachate Management; HELP; SMLRM; DMLRM; BOD; COD; WBM; EPIC; UNSAT-H; HYDRUS-2D; NPK

Introduction

Solid waste management is a difficult task, which includes the control of generation of leachate at the landfill site, composting storage, segregation, collection, transfer and disposal of MSW is an environmentally acceptable manner. Most landfills are unengineered in the country. Therefore there is no any appropriate management of MSW disposal, composting and leachate treatment is being done. The difficulties in providing the desired level of public service in the urban centres are often attributed to the poor financial status of the managing Municipal Nagar Nigam or Corporations. The management of leachate is among the most important factors to be considered in planning, designing, operation and long term management of an MSW landfill the state regulatory authorities such as Nagar Nigam or Nagar Palik or Municipal Corporation in almost all the countries of the world have framed some rules and regulations to safeguard against the contamination of groundwater source from the leachate generated from the landfill site or trenching ground.

Materials and Methods

There are so many materials and technologies were used to manage the quantity and quality of leachate generated, to prevent contamination of groundwater from its effects Leachate Pollution Index (LPI) value can be used as a tool to access the leachate pollu-

tion potential sites particularly at places where there is a high risk of the leachate nitration and pollution of ground water. This technology used has controlled the LPI value of leachate to minimise LPI from 26.45 (before) to 7.03 (after) Treatment [2]. Proper lining of landfill cells and leachate ponds is to be required [3]. Moreover combating impacts such as organic load from leachate may also require MSW undergo one week of bulk composting prior to land filling [3]. Also shredding of MSW is recommended to increase the rate of biological degradation [3].

Leachate generation modeling software packages such as hydrological evolution of landfill performance (HELP) model has been used to estimate leachate generation. This HELP modeling provides estimated values for runoff, infiltration, precipitation, evapotranspiration, and storage for a set of input parameters. According to HELP model results, leachate generation decreases with increasing waste height. The amount of storage within the landfill mass increase with increasing waste height. The majority of precipitation comes out of the landfill as evapotranspiration the amount of it is about twice the amount of leachate generated.

It has been found that HELP modeling consistently predicted higher leachate generation than the other software packages [EPIC, UNSAT-H, HYDRUS-2D).

This HELP modeling under estimated the evapotranspiration rates and even large evaporation depths were required [4].

Various studies on HELP modeling reveal that this method, generally over predicts leachate generation by percolatin accurate preductions of storage would depend on accuracy predicting the relationship between fly ash and moisture content. In this model fly ash materials play an important role to control higher degree of water retention and capillary action near the ground surface. One could hypothesize speculate that the actual evapotranspiration from fly ash materials is much higher than predicted by the HELP model. It is now clear that this model does not give appropriate results regarding leachate generation which were either under estimated or over estimated. The level of compaction of waste material could also be a factor [4].

Experimental and analytical model studies on leachate volume computation from municipal solid waste have also been performed to characterise various hydraulic properties and estimated the leachate flow and total leachate volume for both unsaturated and saturated conditions. The result reveals that the measure of total volume of leachate and its flow using Darcy's law is about the same as found from experimental model and analytical model [5].

There is a need of closer look to the leachate generation process as necessary to achieve a deterministic model, which takes some other leaching models have used in leaching managments are HELP model, EPIC, UNSAT-H, HYDRU-2D, water Balance model (wBm) Deterministic multiple Linear Reservoir (DmLRm) model, Stochastic multiple Linear Reservoir (SMLRM) model, Leachate Generated (LG) model and Bioreacter model. HELP model helps to decrease leachate generation with increasing waste height which also affected evapotranspiration. Water Balance model (wBm) specially focused on the quantity of leachate generated based on precipitation and evaporation pattern. Column testing model emphasised on Liquid Solid ratio (L/R ratio) which indicates the concentration of leachate generated using risk analysis.

A prototype leachate generated model, developed by the researcher, using Gomutra as a stimulator, showed that the pH value of leachate has slightly increased by using @ 5%, 10% and 15% Gomutra, indication of leachate is stablised. Colour of leachate generated was found to be dark brown showed that MSW oxygenated properly. The ratio of BOD and COD showed the age of land fill; in this study the value of BOD/COD was found to be 0.45 which indicates that the age of landfill is more than 5.0 years. The presence of sodium potassium and phosphorus will into account the temporal variations of physical characteristics of the waste was well as climatological data.

Leachate quantity is always an important parameter in leachate management and leachate quantity is usually modelled and/or determined using a water Balance model (wBm), which despite the current rough estimate of annual leachate quantity at the landfill site. Considering the precipitation and evaporation pattern, as well as the concept of field capacity. In this study, moisture content is a key leachate generating component. The proposed model, which were constructed on a conceptual basis. Therefore has been considered a first attempt to determine leachate production rate. In this study data of Field capacity (Fc), moisture content (mc), water consumed in gas generation and the value of water entering/leaving the landfill due to infiltration and evaporation must be available to proper utilisation of the model [6], which could not measured properly.

As stated above there are several numerical models that can be applied to estimate the amount of water infiltrating the landfill and contributing the leachate production examples of there models are DmLRm (Deterministic Multiple Linear Reservoir model) smLRm (stochastic multiple Linear Reservoir model) and the HELP model created by united state EPA. All these models are based on the hydrologic balance inside the landfill.

Use of leaching tests to characterize landfill leachates in the long term period has been done using column leaching test under unaerobic condition in order to determine Liquid Solid Ratio (L/R ratio) which is a more objective tool. In this model waste was mixed with gravel (size 10-15 mm). The results reveals that the leachate concentration presented as a L/S ratio applying risk analysis [7] while Britt matic [8] svenssion used in his column test focused on L/S ratio only.

In this study a prototype leachate generated model has designed to characterize various characteristics of leachate generated and identified its importance in soil conditions, composting as well as behaviour of leachate on ground water.

This model is based on "Layer theory" consists of earth (soil) and waste, provided in alternate form as shown in figure. This model has used to study the effect of Gomutra (used as Stimulator) on the leachate generated from MSW. To stimulate natural conditions of landfill, a water spray system was provided to stimulate rain of 10 mm/hr. (minimum) to 100 mm/hr. (maximum). The leachate developed after 30 days, analyzed its characteristics in the laboratory. The results showed that this model is very useful to control the quantity and quality of leachate generated from MSW and helps to enhance the growth of plants, texture of soil, control pH of soil and leachate reduce soil salinity. This is possible due to application of Gomutra (cow urine) which is a novelty concept in the municipal solid waste treatment in Indian Scenario.

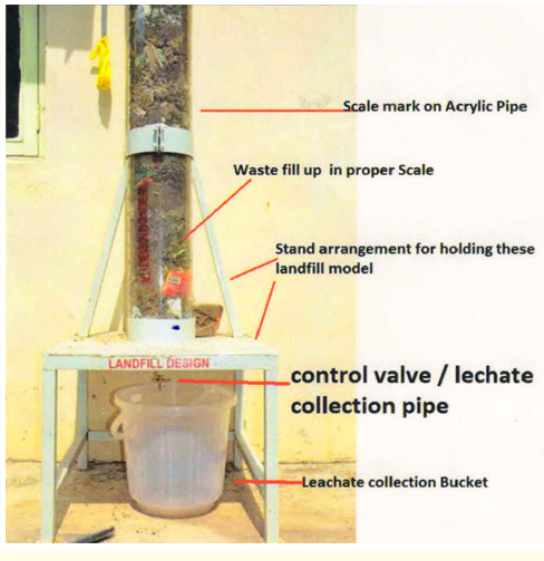

Figure 1: A Leachate generated model.

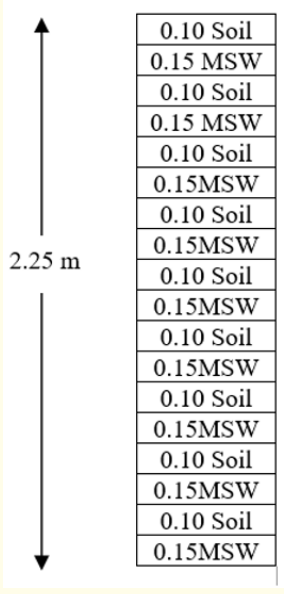

Figure 2: Concept of Layer system.

Results and Discussion

Various Leachate models have been used in Landfill leachate management to manage quantity and quality of leachate generated from municipal solid waste dumped at landfill site leachate pollution index value after treatment. According to this modeling technique proper lining of land fill cells and leachate ponds is required shredding of MSW is also recommended to increase the rate of biological degradation which is an important part of leaching management enhance the growth of plants, and standards of soil. Gomutra is an organic fertiliser and has no any toxic property therefore we can be using it without any harmful reactions.

Conclusions

There are various approaches towards leaching modeling to characterize leachate quantity, quality and concentration of it. Most of the models are required high technologies which are costly having complex mechanisms, long term procedure, controlled any specific characteristics of leachate, required special monitoring predicted either over estimation or under estimation value. The proto type leachate generated model reveals that it can be controlled various characteristics such as temperature, pH value, ratio of BOD and COD, C/N ratio etc. very effectively which help to develop moisture retaining capacity of soil, enhances texture of soil, salinity improved growth of plants, and add many primary nutrients (NPK) as well as secondary nutrients (Ca, Mg and S). Gomutra used

as an organic fertiliser which contains all the nutrients, toxic free easy available, cost free and has no any negative effect on human health and environment. It also prevent contamination of surface water from stabilised and controlled leachate. Using this model, and Gomutra, leaching management can easily be maintained and managed properly.

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