EVALUATION OF LANDFILL COVER SYSTEMS

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Abstract

Landfill is an important component in solid waste management hierarchy. It posed undesired environmental impacts by producing leachate and gases which contaminated water resources, surrounding soil and atmosphere. In view of this, a study was conducted to evaluate the efficiency of landfill final-cover systems performance in preventing water infiltration that produced leachate. Five types of cover systems namely T-1, T-2, T-3, T-4, and T-5 were studied to determine the depth of leachate generated. One of these models, T-4 was selected and further investigated to find the effectiveness of each cover layer based on water balance component (WBC). The parameters studied are topsoil thickness, surface slope, saturated hydraulic conductivity of topsoil, drainage materials and barrier soil layer. The analysis of WBC was carried out using software called VHELP which required meteorological data, such as, daily precipitation, solar radiation, and mean temperature, to execute analysis. Assuming equal surface area of study for the landfill, the model type T-1, which consisted of topsoil and barrier soil layer, generated leachate of depth at 1345.5 mm, with the cost of construction estimated at RM 7/m^2. The type T-2 model cover consisted of topsoil, geomembrane, and barrier soil layer, and generated leachate depth at 960.3 mm with cost of construction at about RM 22/m^2. Type T-3 model cover consisted of three natural layers that are, topsoil, lateral drainage materials, and barrier soil layer, and generated leachate of depth at 660.43 mm, with the cost of construction at about RM 11/m^2. The type T-4 model cover consisted of topsoil, lateral drainage materials, geomembrane, and barrier soil layer, and generated leachate depth at 125.06 mm with the cost of construction at RM 26/m^2. The type T-5 model cover consisted of topsoil, lateral drainage materials, geonet, geomembrane, and barrier soil layer, and generated

leachate at depth of 78.6 mm, and the cost was estimated to be RM 40/m^2. According to USEPA (1995), type T-4 and T-5 cover complied with EPA guidelines where leachate was generated at a depth less than 300 mm. Therefore T-4 which gave comparable efficiency as T-5 model of cover system, was recommended to be more suitable for Malaysian landfills since the cost of T-4 is lower and is economical compared to type T-5 cover. When model T-4 was further studied, a good combination of cover layer was identified for the various functions tested. Various parameter inputs were tested for each component of the cover system. It was found that the topsoil with surface slope less then 5% was the most appropriate since it generated a runoff at a depth of only 204.7 mm. When silty loam soil of hydraulic conductivity of 0.00019 cm/s was used, the evapotranspiration depth was 1860.74 mm compared to minimum of 1515.04 mm. For lateral drainage materials, results showed gravel with hydraulic conductivity of 0.3 cm/s was superior when the drainage water was at depth of 1525.03 mm compared to lowest range of 1206.63 mm. For barrier soil layer, clay with hydraulic conductivity of 68.0 $x10^{-7}$ cm/s gave minimum leachate depth of 162.4 mm, while the maximum was 292.3 mm and therefore the above materials with the corresponding characteristics formed a good combination of final-cover system.

Abstrak

Tapak pelupusan sampah kambus tanah adalah satu komponen yang penting dalam hierarki pengurusan sampah. Tapak pelupusan sampah boleh mencemarkan sumber air, udara, dan alam sekitar dengan penghasilan air sampah dan gas beracun. Oleh yang demikian satu kajian telah dijalankan untuk menilai keberkesanan sistem penutup akhir tapak pelupusan sampah kambus tanah. Usaha ini adalah bertujuan untuk menghindarkan penyisipan air melalui system penutup akhir yang akan menghasilkan air sampah. Lima jenis sistem penutup model T-1, T-2, T-3, T-4, dan T-5 dikaji untuk menentukan penghasilan air sampah. Model T-4 dipilih untuk kajian selanjutnya bagi mencari keberkesanan setiap lapisan penutup berdasarkan komponen keseimbangan air. Parameter-parameter yang dikaji adalah ketebalan tanah atas, kecerunan permukaan, pekali kealiran tanah atas, pekali kealiran bahan pengaliran sisi, pekali kealiran lapisan tanah penghadang. Analisa keseimbangan air dijalankan dengan menggunakan perisian VHELP yang mana memerlukan data cuaca, seperti hujan, pancaran matahari, dan suhu purata. Andaian dibuat ialah menganggarkan luas permukaan tapak pelupusan sampah adalah tetap. Model T-1, yang terdiri daripada tanah atas dan lapisan tanah penghadang menghasilkan air sampah pada sedalam 1345.5 mm dengan kos pembinaan dianggarkan RM $7/m^2$. Jenis penutup T-2 yang terdiri daripada tanah atas , geomembrin dan lapisan tanah penghadang menghasilkan air sampah sedalam 960.3 mm dengan kos pembinaan RM 22 / m^2 . Jenis model penutup T-3 yang terdiri daripada tanah atas, bahan pengaliran sisi, dan lapisan tanah penghadang menghasilkan air sampah sedalam 660.43 mm pada kos pembinaan RM 11/ m^2. Jenis model penutup T-4 yang terdiri daripada tanah atas, bahan pengaliran sisi, geomembrin, dan lapisan tanah penghadang menghasilkan air sampah sedalam 125.06 mm dengan kos pembinaan

RM 26 / m^2. Jenis model penutup T-5 terdiri daripada tanah atas, bahan pengaliran sisi, geonet, geomembrin, dan lapisan tanah penghadang menghasilkan air sampah sedalam 78.6 mm pada kos pembinaan RM 40 / m^2. Menurut USEPA (1995), jenis T-4 dan T-5 mematuhi garis panduan EPA kerana menghasilkan air sampah pada kedalaman kurang daripada 300 mm. Oleh yang demikian model T-4 dicadangkan supaya digunapakai di Malaysia kerana harganya agak ekonomik jika dibandingkan dengan model T-5. Kajian lanjut model T-4 dibuat untuk mencari satu kombinasi lapisan penutup yang berkesan. Pelbagai fungsinya diuji. ke atas lapisan tersebut. Hasinya didapati tanah atas pada kecerunan permukaan kurang daripada 5 % merupakan yang paling sesuai kerana hanya menghasilkan air larian permukaan pada kedalaman 1860.74 mm, apabila menggunakan tanah 'silty loam' dengan pekali kealiran 0.00019 cm /s. Manakala bahan pengaliran sisi, dengan pekali kealiran 0.3 cm / s menghasilkan air pada kedalaman 1525.03 mm. Lapisan tanah penghalang pula dengan pekali kealiran 6.8 X 10 -3 cm /s menghasilkan air sampah sedalam 162.4 mm, oleh itu bahan-bahan tersebut di atas dapat menghasilkan kombinasi berciri baik bagi penutup akhir tapak pelupusan sampah di rantau ini.

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LIST OF ABBREVIATIONS

ARS- Agriculture Research Service

BOD- Biochemical Oxygen Demand

CCL- Compacted Clay Liner

CERCLA- Comprehensive Environmental Response, Compensation and Liability Act

CH_4- Methane

CN- Curve Number

CO_2- Carbon Dioxide

CR- Construction Refuse

CREAMS- Chemical Runoff and Erosion from Agricultural Management Systems

DG - Director General

DOE- Department of Environmental

DR- Domestic Refuse

EIA- Environmental Impact Assessment

EIS- Environmental Impact Statement

EPA - Environmental Protection Agency

EQA – Environmental Quality Act

GCL- Geosynthetic Clay Liner

GM- Geomembrane

GR- Garden Refuse

HELP- Hydraulic Evaluation Landfill Performance

HSSWDS- Hydraulic Simulation Model for Estimating Percolation at Solid Waste Disposal Sites

LCRS – Leachate Collection and Removal System

MSW- Municipal Solid Waste

NEPA- National Environmental Policy Act

NWSRFS- National Weather Service River Forecast System

OND- Other Non Dangerous

PFA- Pulverised Fuel Ash

RCRA- Resource Conservation and Recovery Act

RRA- Resource Recovery Act

SCS- Soil Conservation Service

SIC- Standard Industrial Classification

SWDA- Solid Waste Disposal Act

SWRRB- Simulator for Water Resources in Rural Basins

UK- United Kingdom

USA- United States of America

USDA- United States Department of Agriculture

USCS- Unified Soil Classification System

USEPA- United States Environmental Protection Agency

USPHS- United States Public Health Service