Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 95 (2016) 140 – 144

Energy Procedia

International Scientific Conference "Environmental and Climate Technologies", CONECT 2015, 14-16 October 2015, Riga, Latvia

The effect of particle size distribution on hydraulic permeability in a waste mass

Sabina Gavelyte[a,b]*, Elina Dace[a], Kristina Baziene[b]

[a]*Institute of Energy Systems and Environment, Riga Technical University, Azenes iela 12/1, Riga, LV–1048, Latvia*
[b]*Department of Environmental Protection, Vilnius Gediminas Technical University, Sauletekio al. 11, LT–10223 Vilnius, Lithuania*

Abstract

In the waste management hierarchy, the least preferable option is waste disposal. Nonetheless, disposal is an integral part of any waste management system. In a landfill, during waste degradation processes leachate is formed that can potentially cause clogging of bottom drainage layers. To ensure stability of landfill construction, the physical properties of its components have to be controlled. In a landfill, waste presents the largest structural element and often controls both the stability and integrity of the lining system. The hydrology of precipitation, evaporation, runoff and the hydraulic performance of the capping and liner materials are important controls of the moisture content. It is important to understand the hydrology of a landfill site as it affects sustainability of landfill leachate management system. The water balance also depends on waste characteristics and waste particle size distribution. Waste characteristics are closely related to the waste composition in a landfill. The aim of the study is to determine the hydraulic permeability in a landfill depending on the particle size distribution of municipal solid waste disposed. Samples were taken from a landfill operating for five years. The samples were sorted to obtain fractions with differing particle sizes. The largest fraction of the waste was within the size-range of 20–100 mm. The permeability test was conducted using the column test. The paper presents the results of the test indicating higher permeability with larger waste particle size.

Peer-review under responsibility of Riga Technical University, Institute of Energy Systems and Environment.
Keywords: particle size; water permeability; municipal solid waste; landfill; physical properties

* Corresponding author. Tel.: +370-626-81302
E-mail address: sabina.gavelyte@vgtu.com

Peer-review under responsibility of Riga Technical University, Institute of Energy Systems and Environment.
doi:10.1016/j.egypro.2016.09.035

1. Introduction

Although landfilling of waste is the least favourable waste management option, it is still widely used in the world. Even European Union countries, where the waste management hierarchy was developed, struggle with diverting waste from landfills. Landfilling is defined as the disposal of waste materials at a specifically designed site, usually in the soil or shallow vadose zone [1]. Many landfills are constructed as land raise features on top of the original ground surface. In this case, the topography naturally restricts the inflow of surface- and groundwater into the landfill [2]. Still, utter avoidance of water in a landfill structure is impossible, as precipitation and the internal moisture of landfilled waste add water to the waste mass disposed. After percolating through the waste mass, a liquid containing various substances extracted from waste forms. This liquid is called leachate.

It is important to gain an understanding of the factors governing the hydraulic properties of waste, and their impact on the flow of liquids within the waste mass [3]. To ensure stability of landfill construction, the physical properties of its components have to be well known [4]. In a landfill, the largest structural element is the disposed waste that often controls both the stability and integrity of the landfill's structure. The hydrology of precipitation, evaporation, runoff and the hydraulic performance of the capping and liner materials are important controls on moisture content. Yet, the water balance in landfill also depends on waste characteristics where waste characteristics are relate to the waste composition disposed in the landfill. The waste composition in landfill, in turn, depends on waste sorting and pre-treatment prior to filling.

The EU Landfill Directive requires, amongst other things, that biodegradable waste is stabilized prior to disposal in a landfill to prevent greenhouse gas emission generation and to lessen leachate formation. A range of processes known generically as mechanical-biological treatment have become popular throughout Europe to enable compliance with this requirement [5]. The stability is often described as „the point where biological activity is complete". However, a reduction in biological activity does not always indicate that biological activities are complete, and there may be other factors influencing this activity [6]. In addition, biodegradable waste is characterized by smaller particle size than that of other materials (glass, plastics, rubber, etc.) landfilled. Particle size is an important characteristic that impacts the water permeability within the landfill structure, thus determining the amount and composition of leachate formed. Furthermore, the particle size can potentially cause clogging into drainage layers and piping system of leachate collection. Leachate management is an integral part of modern sanitary landfills and constitutes a considerable share of landfill operation costs. Therefore, it is important to understand the leachate formation processes.

The particle size distribution determines the suitability of waste for specific mechanical treatment and sorting methods. Furthermore, according to Bilitewski et al. (1994) [7], the waste type represented in each particle-size category should determine the development of each process technology for reaching maximum material recovery with minimum contamination levels. The particle size distribution is also used for assessing permeability, compressibility and other mechanical properties of waste [2]. Several methods exist for determining the particle size, e.g. dry and wet sieving. Regardless of the selected method, the particle size is determined by sieving the waste mass through a series of standard sieves and weighing the material retained in each sieve. Then, the cumulative percentage of weight passing each sieve is calculated [2].

Tchobanoglous et.al. (1993) [8] show that typical component size of most material fractions in residual waste is in the range of 30 to 250 mm. The size of food waste typically does not exceed 180 mm. The experimental results presented by Gomes et.al. (2013) [9] indicate that ageing of waste (including degradation and stabilization of bio-waste) leads to a decrease in particle size, as the relative quantity of mineral and non-identifiable components increases. In their experiments, Gomes et al. (2013) [9] used waste excavated from different depths of a landfill. They found that up to 50 % of the excavated waste was in the particle size range of 0.1 to 10 mm.

In this study, the hydraulic permeability of waste in a landfill (or, in other words, water filtration through the disposed waste mass) depending on the particle size distribution of the waste disposed was determined. The paper presents the results of the particle size distribution and permeability tests conducted by using waste excavated from a landfill in Lithuania. In Lithuania, waste sorting is relatively basic in comparison to more advanced techniques used in Western European countries [10, 11]. Therefore, in Lithuanian landfills, a high fraction of biodegradable waste is present. Several experiments have been conducted in Lithuania determining the chemical composition of leachate or clogging [12]. Yet, this is the first study where the physical parameters of waste that determine the leachate formation are assessed.