Conditioned Upshots of Permeation Rates as a Function of Vadose Zone Effect in Engineered Landfill Clayey Medium

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Abstract

In has long been established that the escape and consequent permeation of landfill leachate through a barrier medium is one of the contributing factors to environmental contamination, especially where vital regions with consequential impacts are concerned as in the case of soil, surface, subsurface and groundwater pollution. Although the contamination process of environmental resources from leachate permeation may be slow, it poses a significant threat to human and environmental health in the long run. These challenges paved way for the study to evaluate via laboratory tests the permeation rates of a landfill mineral lining system as compacted clay liner (CCL) overlain an unsaturated/ vadose and saturated zone of known thicknesses respectively. The laboratory permeation tests were conducted to simulate the moisture flow regime and steady/ quasi steady-state permeation rates for typical conditions of a landfill. The results of the tests revealed the hydraulic conductivity of the fine textured vadose zone to be 1-2 magnitude in order lesser than the saturated zone hydraulic conductivity. Nonetheless, the hydraulic conductivity of the mineral barrier and the permeation rate to underlying groundwater was found to dependent on the nature of the zone as the last line of defense to contaminant permeation in the event of leachate breakthrough. Thickness values of up to 225 mm for the fine textured zones were reached which appeared to be functional parts of the tested landfill mineral liner. Consequently, the vadose zone was found to behave better than the saturated zone in the permeability of the overall lining system as such, upshots of the tests showed permeability coefficient of the CCL of 24 mm natural clay mineral liner to be the key regulator of the steady/ quasi steady-state permeation rates in the overall system lining setup.

Keywords
Clayey, Leachate, Permeation, Saturated, Vadose zone

1. Introduction

The escape and eventual permeation of leachate through landfill liners as reported by Rowe (2011) is one of the major challenges to soil, surface, subsurface and groundwater contamination. It has been established that in South Africa as in many parts of the world, composite lining systems comprising of either a geomembrane (GM) or geosynthetic clay liner (GCL) and compacted clay liner (CCL) are used in waste containment facilities. Significant research have been done and more are ongoing on factors and effects of leachate permeation through landfill lining liners (Touze-Foltz et al., 2006). Similarly, studies by Rowe et al., (2004) showed how single low permeability clay liners have been effective in containing advective leachate permeation to regions of consequential impacts. It has been established that in the absence of a GM but with a leachate collection system (LCS) of typical design heads up to 0.3 m, CCL dependent on the natural geology/ aquitards can prevent leachate permeation through landfill liner systems thus, curbing the permeation of contaminant species into vital regimes (Rowe, 2005). Therefore, the design and construction of landfill lining systems require the incorporation of appropriate laboratory modelling with relevant parameters such that, the potential impact of a proposed liner system can be determined. By and large, software and laboratory landfill models employ Darcy's law to evaluate leachate permeation through barrier systems to groundwater levels. As such, Bouazza et al., (2002) reported that the selection of suitable permeability coefficients for CCL and the underlying soil zone is a critical estimation in preventing permeating contaminants in the case of leachate breakaway due to membrane defects or failures. Hence, with respect to the vadose/ unsaturated zone, Freudlund and Raharjdo (1993) proposed that the permeability coefficient of soils is a function of pore-water pressure regardless of the drastic changes that could occur in the vadose zone prompted by minute variation in the soils moisture content. It has therefore been observed that most laboratory tests and modelling software appraise permeation rates by single uniform permeability coefficient value for the CCL, disregarding the reliance of permeability on moisture content (MC) in the vadose zone. This leaves a clear implication that permeation rates of escaped leachate underneath the containment liners are often miscalculated or misjudged thereby leading to severe contamination in the event of a contaminant escape in landfills. Moreover, it is noted that the permeation through the entire liner system is reliant on the type and sequence of the layers. It is for such reasons that this laboratory study assessed the permeation rates of landfill leachate using a bespoke hybrid percolation device. In this study, steady/ quasi steady-state permeation rates into groundwater reserves/ aquifer through CCL as landfill liner system overlying the vadose and saturated zones of known thicknesses was evaluated. The zones were tested as fine textured clayey soils collected from a landfill site in the City of Johannesburg (CoJ). The effects of permeation rates on uniform saturated and unsaturated permeability values, soil texture and the permeability of CCL were appraised in this studied. However, only the case of a single low conductivity CCL overlying a soil zone was investigated as it represents most of the scenarios around the visited landfills in the CoJ, South Africa. Furthermore, the study offers a more conservative scenario dependent on the geology of a typical dump site as compared to cases of engineered landfills with composite barrier systems i.e., incorporating a LCS, GM or GCL, to a CCL overlying a soil zone. Therefore, the results presented here are recorded to be conservative of cases on composite landfill lining systems.

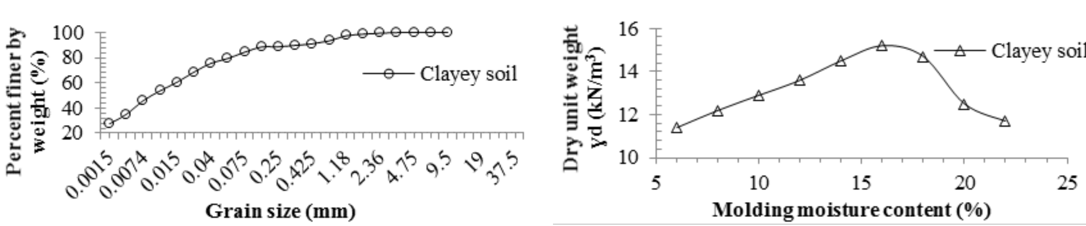
2. Materials and Method

2.1 Experimental Approach

In this study, the fine textured soil was sampled as clayey material used as the CCL, saturated and unsaturated/ vadose zones. The clayey soil was collected in Johannesburg, South Africa, around a landfill site slightly remote from the dump ground in order to ensure a degree of purity of the samples as presented in Figure 1.

Figure 1. Sampling areas

The soil sample was mechanically tested to determine its characteristic properties. Figure 2 presents the grain size distribution curve of the sample as well as its compaction curve showing the relationship between optimum moisture content (OMC) and maximum dry unit weight (MDUW) determined by compaction test in consonance with American Society for Testing and Materials (2012).



(a) (b)

Figure 2. (a) Grain size distribution curve for the clayey soil; (b) Clayey soil compaction curve for clayey soil

The standard proctor compaction was achieved with a light self-weighted rammer of about 0.0244 kN and striking effort of about 595 kN-m/m^3. The tests yielded OMC of 16.2 % and MDUW of 15.6 kN/m^3 for the liner while the saturated and vadose zones had MDUW and OMC of 11.7 kN/m^3 and 22 % and 11.4 kN/m^3 and 6 % respectively. Values for permeability coefficient determined in consonance with American Society for Testing and Materials (2006) were measured by falling head test. The vadose zone was prepared with relatively low water content while the saturated zone had high water content. The soil zones were lightly compacted to best simulate in-situ conditions of the natural soil respectively. The relationship between the permeability and dry unit weight of the soil used as liner is shown in Figure 3. The leachate used in the study was collected from a pond at the site. The pond held generated leachate formed by decomposed waste, infiltrated storm water and/ or intercepted surface water in contact with the waste pile in-situ presented in Figure 4.

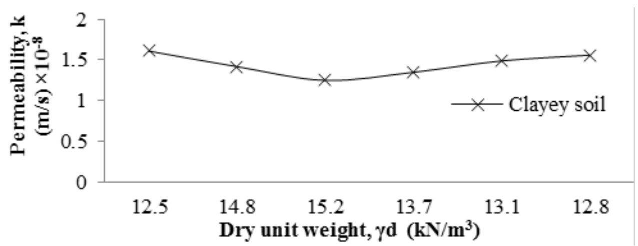
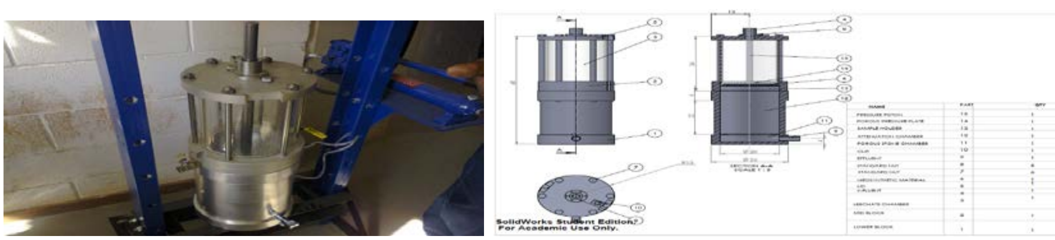


Figure 3. Permeability variation of clayey soil liner

Figure 4. Leachate collected from pond

The actual landfill leachate was of interest to the study such that at best, real life permeation conditions during the leachate-soil interaction can be visibly simulated and monitored in the laboratory. More so, this was done in attempt to validate results of similar studies conducted with respect to landfill leachate migration through defected lining barriers (Agbenyeku and Akinseye, 2015; Agbenyeku et al., 2014a, b; 2013a, b). On the bespoke device, the leachate chamber was marked to hold a constant head of 250 mm but since the mechanism to keep constant head was not designed for in the device, it was maintained by manually topping up the leachate level as it dropped throughout the test duration. A pictorial and schematic view of the bespoke device is presented in Figure 5.



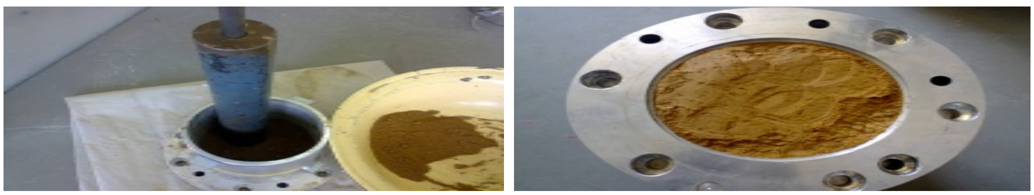
(a) Pictorial view (b) Schematic view

Figure 5. Bespoke percolation column hybrid device

For this test, the bespoke device comprised of three sections: (1) the bottom part called the bucket section; which contained the vadose/ unsaturated and saturated soil of 225 mm thickness respectively, simulating the zones below the liner as presented in Figure 6. (2) the mid-block called the liner holder; which contained the compacted soil liner (natural clayey soil as CCL) overlying the respective zones as seen in Figure 7, and (3) the upper part above the soil liner; which functioned as the leachate pond as shown in Figure 8 was filled with de-ionized water to saturate the system prior the addition of the actual leachate. Soil layers were prepared in the bottom section and the mid-block sample holder and leakage free assemblage was ensured by using O-rings, gasket corks and sealants to secure an airtight connection of the device. The leachate was then added and the vertical hydraulic conductivity, k_z value, in stratified soil (overall hydraulic conductivity of barrier-vadose system) was calculated and used to determine the percolation rate, Q, through the entire system on the assumption that since the barrier liner and the soil zones are not in direct contact, leachate that percolated the barrier went straight into the zones. This was further benched on the fact that the hydraulic conductivities of the soil zones were higher than the CCL since the zones were only lightly tampered to simulate a porous substrate and was not prepared at OMC.

(a) (b)

Figure 6. (a) Wetted geotextile on porous stone to prevent outlet clogging; (b) Lightly rammed compacted simulated vadose/ saturated and unsaturated zone in the chamber



(a) (b)

Figure 7. (a) Standard proctor compaction of soil (as CCL) in liner holder; (b) Designed barrier liner

(a) (b)

Figure 8. (a) De-ionized water in chamber; (b) Actual leachate in chamber

The leachate was then introduced and the vertical hydraulic conductivity, k_z value, in stratified soil (overall hydraulic conductivity of liner-vadose system) was calculated and used to determine the permeation rate, Q, through the entire system on the assumption that since the liner and the soil zones are not in direct contact, leachate that permeated the liner went straight into the zones. This was further benched on the fact that the hydraulic conductivities of the soil zones were higher than the CCL since the zones were only lightly tampered to simulate a porous medium and was not prepared at OMC. This part of the experimental work studied the changes in the hydraulic conductivity through the soil-leachate interaction. Four main test series were structured and conducted in this study besides other confirmatory tests. Nevertheless, the boundaries of the two series of main concern in the study are reported herein.

Therefore, "Equations (1) to (3)" were used to determine:

The hydraulic conductivity (k) expressed as;

$$k = QL/Ath \qquad (1)$$

Where; k is the hydraulic conductivity, Q, is the volume of water collected, L, is the length of the sample, A, is the cross-sectional area of the sample, t, is the duration of effluent collection and h, is the total head. While the hydraulic conductivity of a liner-soil zone (stratified soil layer) system was calculated and used to determine the permeation rate through the entire system. The vertical hydraulic conductivity in a stratified soil (k_z) is given as;

$$k_z = \sum H_i / \sum H_i/k_i$$

Hence,

$$k_z = H_1 + H_2/(H_1/k_1) + (H_2/k_2) \qquad (2)$$

Where; k_z is the vertical hydraulic conductivity in a stratified soil, H_1, is the thickness of the liner, k_1, is the hydraulic conductivity of the liner, H_2, is the thickness of the soil zone, k_2, is the hydraulic conductivity of the soil zone. The permeation rate through the entire system for the test by Darcy's Equation is expressed as;

$$Q = k\,\Delta h A/L \qquad (3)$$

Where; k = hydraulic conductivity of the entire system, Δh = leachate head drop, A = cross-sectional area of the system and L = thickness of the liner-soil zone system. The clayey soil was moulded with de-ionized water and compacted in the mid-block to simulate water-wet clay liner. The samples in the bucket section were gently compacted to simulate a loose substrate layer as the soil zone thereby increasing its porosity and hydraulic conductivity.

3. Results and Discussion of Finding

3.1 Measurement of Leachate Permeation Rate

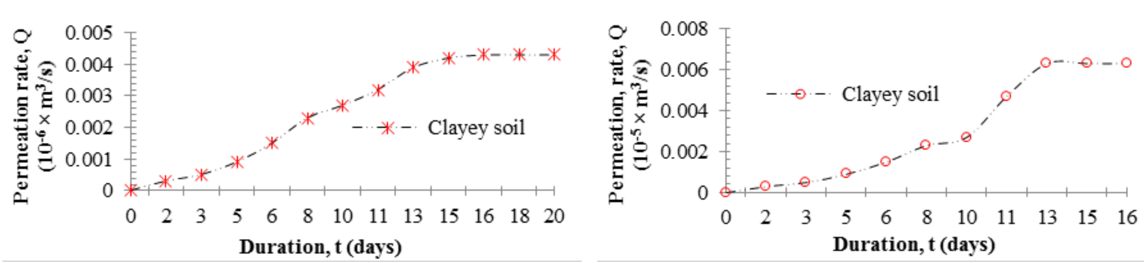
Two main test series were adopted in this study besides the confirmatory tests conducted. A summary of the test conditions applied in the study are presented in Table 1. The observed leachate-liner soil interaction from permeation behaviours through the lining system are recorded.

Table 1. Test series and boundaries applied in the study

Test No.	Barrier as CCL		*Eft	Soil as vadose zone		**Eft
	MDUW (kN/m^3)	OMC (%)		MDUW (kN/m^3)	MC (%)	
1	15.2	16	25b/l	11.4$^+$	6$^+$	Gentle
2	15.2	16	25b/l	11.7^{++}	22^{++}	Gentle

*****Standard Proctor Compaction Test (ASTM D-698) $^+$Unsaturated/ Vadose zone
******Lightly compacted to simulate a loosed substrate $^{++}$Saturated zone

For each test conducted, measurements were taken subsequent to the introduction of the actual test leachate into the leachate chamber. This was done after the hydraulic conductivity value using de-ionized water as initial permeant stabilized to values in the order of 10^{-7} to 10^{-8} m/sec. The results of the permeation rates in the overall lining system for the vadose and saturated zones are graphically presented in Figure 9 respectively. A wet geotextile placed over the porous stone served as filter to moving fines as such, prevented clogging of the chamber outlet. However, because of the temperature variations and atmospheric conditions, it was difficult to arrive at an absolute steady state in the laboratory. Nevertheless, for the purpose of this work the steady state adopted, implied a relatively steady/ quasi steady state. In view of the vadose zone test, it was observed that by day 16 steady/ quasi steady state was reached however, to carter for factorial changes, the test was monitored up to 20 days. As presented in Figure 9 (a), the permeation rate, Q, for the overall lining system for vadose zone was observed to gradually increase to a steady value of 0.0043×10^{-6} m^3/s after breakthrough was reached.



(a) (b)

Figure 9. (a) Percolation rate against time for vadose zone; (b) Percolation rate against time for saturated zone

Considering the saturated zone, it was observed that by day 13, steady/ quasi steady state had been reached however, to also carter for factorial changes, measurements were taken up to 16 days. Furthermore, the permeation rate, Q, for the overall lining system with saturated zone as shown in Figure 9 (b) was observed to gradually increase to a steady value of 0.0061×10^{-5} m^3/s after breakthrough was reached. Pressure effects on the liner in this study were neglected i.e., p = 0 kPa since it is considered that the constant low leachate head of 250 mm adopted in the study would have negligible impact on the percolation rate as recorded by Rowe (2011). Additionally, previous studies by the authors have already investigated the effect of waste load on leachate migration through barrier liners (Agbenyeku and Akinseye, 2015; Agbenyeku et al., 2014a, b; 2013a, b). Consequently, a 1 - 2 order of magnitude difference was recorded between the vadose and saturated zone tests. The conceivable cause could be the difference in pore-water pressure; as the hydraulic conductivity of soil is a function of MC as such, increases with increased moisture intake. Also, the loose cohesive force between the soil particles of the saturated zone and the light compaction contributed by allowing easier flow thus, accounting for the higher permeation rate than in the vadose zone. Rowe et al., (2004) also reported similar observations as compared to the study herein.

3.2 Behaviour of Clayey Vadose and Saturated Zones Underlain a CCL Barrier System

Considering the permeation rates of the liner system with fine textured soil zone, it is evident that there is significant difference between the lining system of the vadose and saturated zones. It has therefore been determined through laboratory soil mechanical and permeation tests that water content, pore-water pressure and soil density can affect the hydraulic conductivity of lining systems with respect to the soil zone. The permeation rate measured for a structure of vadose zone was 1 - 2 orders of magnitude less than the saturated zone structure. As such, for laboratory simulated 225 mm thickness of vadose and saturated zones under similar boundary conditions (i.e., MDUW, OMC and thickness for the designed clayey soil liner), no considerable threat will be posed by the hydraulic conductivity and permeation rate to vital ground regimes in a case of contaminant breakaway from landfills. This is basically drawn from the consideration of the 24 mm designed liner (CCL) tested in the laboratory relative to the standard 150 mm CCL employed in landfills. Moreover, retention capacity due to density and waste load effects will be expected thereby further reducing the permeation rates substantially in real life cases.

3.3 Effect of Clayey Soil as CCL on Permeation Rate of a Lining Medium

The effect of natural mineral soil to hydraulic conductivity as CCL and its behaviour on the overall performance of a liner system was assessed from the permeability test conducted under various MDUW. The hydraulic conductivity value of 1.41×10^{-8} m/s for the CCL overlain both the vadose and saturated zones was observed to decrease to steady/ quasi-steady state. The permeation rates into groundwater as estimated in the study for the overall lining system was presented in Figure 10. Therefore, the effect of hydraulic conductivity of the mineral soil as CCL was observed to be highly influential over the tested zones. Furthermore, it becomes pertinent that the hydraulic conductivity of the mineral soil liner be critically taken into cognizance during the design stages of a functional mineral lining system. More so, it has been significantly established in this study by laboratory simulation of permeation tests that the soil liner contributes a major controlling factor for leachate permeation into ground regions with consequential effects.

3.4 Influence of Vadose Zone in the Containment of Contaminant Permeation

The increase in soil thickness sandwiched by a liner underlain a groundwater regime considerably decreases advective and diffusive contaminant permeation to vital regions (Rowe, 2007). Nonetheless, the efficiency of the vadose zone as containment to permeating contaminants is highly dependent on the water content, pore pressure and the nature of the leachate contaminant. Non-volatile contaminants will easily diffuse through water but not air. Therefore, vadose soil as observed from the study forms a better barrier against permeating leachate contaminants than saturated soil. In the case of a diffusive permeation, Rowe et al., (2004) suggested that the contaminants can only diffuse through the water phase as such, a saturated soil offers such medium for diffusive contaminant permeation. Bearing this in mind, Rowe et al., (2004) proposed equations for estimating coefficient of diffusion for vadose soils. Whereas in the case of volatile contaminants in forms of dichloromethane, 1,2 dichloroethane, trichloroethene (trichloroethylene), benzene, toluene, ethylbenzene, m&p-xylene and o-xylene, diffusion will occur in a higher magnitude faster in a dry medium than through a saturated medium. However, in the case of a vadose medium, the contaminants will diffuse in both the gaseous and dissolved phases. It is pertinent to emphasize that diffusion will mainly occur through the gas-filled pores if the water content is low enough to have considerable number of continuous gas-filled pores.

4. Conclusions

This study investigated on soil mineral lining systems to determine the effect of vadose zone on leachate permeation behaviour. A laboratory fabricated permeation column hybrid device was employed in the testing procedure with materials sampled from an active landfill site around the CoJ. The overall permeation rate, Q for the lining system was determined under certain boundary conditions presented in the study. It was therefore emphasized that failure to consider the presence of a vadose zone underlying a CCL can result in significant underestimation of the permeation through the clayey liner, thereby leading to consequential effects to sensitive underground regimes on the event of a contaminant escape from landfills. This consideration is based on the effect of the vadose zone on the permeation through the CCL. It was also noted that hydraulic conductivity of a soil is a function of water content among other factors. Therefore from the results and analysis, the following conclusions were reached:

- In the fine textured soils, the vadose zone was observed to have 1 - 2 difference in order of magnitude lesser than the saturated zone; which was conceivably due to the difference in MC, pore-water pressure and density of zones.
- The permeation rate for the overall mineral lining system for the vadose and saturated zones were determined as 0.0043×10^{-6} m^3/s and 0.0061×10^{-5} m^3/s after breakthrough was reached respectively.
- In the permeability of the overall lining system, the vadose soil zone was found to behave better than the saturated soil zone.
- In an event of contaminant breakaway, the vadose zone can function as advective barrier as was the case in the study, as well as an effective diffusive barrier.
- The tests revealed the permeability coefficient of the CCL to be the key factor of steady/ quasi steady-state permeation rates through the overall barrier system.

In a nutshell, the effect of hydraulic conductivity of the mineral soil as CCL was observed to be highly influential over the tested zones. Hence, it is important that critical considerations be given in the design of a functional mineral lining systems. Finally, the study has significantly established by laboratory simulation of permeation tests that the soil liner contributes a crucial controlling feature for leachate permeation into regimes with consequential effects.

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References

Agbenyeku E.E. & Akinseye S.A. 2015. Leachate Percolation through Failed Geomembrane of a Geo-Composite Soil Barrier *World Journal of Environmental Engineering, 2015, Vol. 3, No. 2, 52-57.*

Agbenyeku E.E. Muzenda E. & Msibi I.M. 2014a. "Zeolitic Mineral Liner as Hydraulic and Buffering Material", International Conference on *Earth, Environment and Life sciences* (EELS-2014) Dec. 23-24, 2014 Dubai (UAE).

Agbenyeku E.E. Muzenda E. & Msibi I.M. 2014b. "Buffering of TOC-Contaminant Using Natural Clay Mineral Liner", International Conference on *Earth, Environment and Life sciences* (EELS-2014) Dec. 23-24, 2014 Dubai (UAE).

Agbenyeku E.E. Okonta F.N. & Ojuri O.O. 2013a. Leachate Flow through Composite Barrier from Defected Geomembrane. 2nd African Regional Conference on Geosynthetics, Accra, Ghana, 18-20 November (CD ROM).

Agbenyeku E.E. Okonta F.N. & Ojuri O.O. 2013b. Evaluation of Empirical Equations for Leachate Migration through Composite Barrier with Defected Geomembrane. 2nd African Regional Conference on Geosynthetics, Accra, Ghana, 18-20 November (CD ROM).

American Society for Testing and Materials 2006. Standard Test Method for Permeability of Granular Soils (Constant Head). ASTM D-2434.

American Society for Testing and Materials 2012. Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3)). ASTM D-698.

Bouazza A. Zornberg J.G. & Adam D. 2002. Geosynthetics in waste containment facilities: recent advances. *Proceedings 7th International Congress on Environmental Geotechnics*, Delmas, Gourc & Girard (eds): 445-507.

Freudlund D.G. & Raharjdo H. 1993. Soil Mechanics for Unsaturated Soils. John Wiley and Sons Inc., USA. pp. 136–140.

Rowe R.K. 2005. Long-term performance of contaminant barrier systems 45th rankine lecture. Geotechnique 55 (9), 631-678.

Rowe R.K. 2007. Advances and remaining challenges for geosynthetics in geoenvironmental engineering applications, 23rd manual Rocha lecture. Soils and Rocks 30 (1), 3–30.

Rowe R.K. 2011. Systems engineering; the design and operation of municipal solid waste landfills to minimize contamination of groundwater. Geosynthetics International, September, 18 (6), pg: 319-404.

Rowe R.K. Quigley R.M. Brachman R.W.I. & Booker J.R. 2004. Barrier Systems for Waste Disposal Facilities. Taylor & Francis Books Ltd. (E&FN Spon), London. p. 587.

Touze-Foltz N. Duquennoi C. & Gaget E. 2006. Hydraulic and mechanical behavior of GCLs in contact with leachate as part of a composite liner. Geotextiles and Geomembranes 24 (3), 188-197.

Biographies

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Edison Muzenda is a Full Professor of Chemical and Energy Engineering, Head of the Chemical, Materials and Metallurgical Engineering Department, and Associate Dean Responsible for Research and Postgraduate Studies in the Faculty of Engineering and Technology at the Botswana International University of Science and Technology. He is also presently a Visiting Full Professor of Chemical Engineering at the University of Johannesburg (UJ), South Africa where he was formerly a Full Professor of Chemical Engineering, the Research and Postgraduate Coordinator as well as Head of the Environmental and Process Systems Engineering and Bioenergy Research Groups. More to this, he was also Chair of the Process Energy Environment Technology Station Management Committee at the UJ. He has a well-grounded academic research background, as he holds a BSc Hons and PhD in Chemical Engineering from Zimbabwe and Birmingham, UK respectively. He has over 20 years' experience in academia mostly gained during his time at various institutions including the National University of Science and Technology, Zimbabwe, University of Birmingham, University of Witwatersrand, University of South Africa, UJ and the Botswana International University of Science and Technology. Through the course of his academic preparation and career, he has successfully held several management and leadership positions. He also holds teaching interests and expertise in unit operations, multi-stage separation processes, environmental engineering, chemical engineering thermodynamics, professional engineering skills, research methodology as well as process economics, management and optimization. Professor Edison is a recipient of several awards and scholarships for academic excellence, one of them being recently nominated as an Outstanding Researcher for an African Researcher Booklet by the Department of Science and Technology, South Africa in 2017. However, with respect to greener energy demands and changing times, his research interests shifted to bioenergy engineering, sustainable and social engineering, integrated waste management, air pollution, and separation processes as well as phase equilibrium measurement and computation. In more recent times, his research activities are mainly focused on WASTE to ENERGY projects particularly, biowaste to energy for domestic and vehicular application in collaboration with South African National Energy Development Institute (SANEDI) and City of Johannesburg (CoJ) with strong involvements in waste tyre and plastics utilization for fuels and valuable chemicals in collaboration with Recycling and Economic Development Initiative of South Africa (REDISA). Professor Edison has contributed to over 360 international peer reviewed and refereed scientific articles in the form of journals, conferences books and book chapters. He has also supervised over 30 postgraduate students and more than 260 Honours and BTech research students. He presently serve as reviewer for a number of reputable international conferences and journals, and also a member of several academic and scientific organizations including the Institute of Chemical Engineers, UK, South African Institute of Chemical Engineers and International Society for Development and Sustainability amongst others, while being an Editor for a number of Scientific Journals and Conferences including the South African Journal of Chemical Engineering. He has organized and chaired several international conferences and remains a member of the South African Government Ministerial Advisory Council on Energy and Steering Committee of CoJ – University of Johannesburg Biogas Digester Project amongst other domestic and international involvements.