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Study on the Natural Soil Properties Endau Rompin National Park (PETA) as Compacted Soil Liner for Sanitary Landfill

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Abstract: The sanitary landfill plays an important role in the framework of solid waste disposal. A liner is a very important component in the landfill as a barrier to leachate migration into the environment. If the landfill system is not well managed it will contaminate the soil and ground water, thus presenting a risk to human and environmental health. The objective of this study is to investigate the natural soils properties at Endau-Rompin National Park (PETA), Johor that are suitable as a compacted soil liner. There are two locations of soil sampling i.e. Kampung Peta (KP) and Nature Education and Research Centre (NERC). The soil samples were taken to geotechnical and Environmental Engineering Laboratory UTHM for analysis of soil characteristics and its chemical compositions. The tests were sieve analysis, particle size analyzer, Atterberg limits, specific gravity, and X-Ray Fluorescence. The results revealed that the natural soil properties are capable of meeting the criterion and suitable to be used as a compacted soil liner for sanitary landfill. The results revealed gravels less than 30%, sands less than 70%, silts and clays greater than 20%, and Plasticity Index less than 30%. The chemical compositions at KP for SiO_2, Al_2O_3, Fe_2O_3, TiO_2, and K_2O are 56.3%, 27.8%, 12.6%, 2.2%, 0.43% respectively. NERC, its chemical compositions for SiO_2, Al_2O_3, Fe_2O_3, TiO_2, and K_2O are 69.8%, 23.2%, 5.0%, 1.25%, 0.32% respectively. Therefore, the natural soil properties at KP and NERC, Endau-Rompin National Park (PETA) are suitable to be used as a compacted soil liner for sanitary landfill.

Keywords: Compacted Soil liner, Sanitary Landfill, KP, NERC, and Endau-Rompin National Park (PETA)

1. Introduction

Land disposal of waste has been practiced for centuries. For nonhazardous waste the emphasis was on transforming waste dumps into "sanitary landfills" [1]. Nowadays, sanitary landfill is a major component of the solid waste disposal system in almost every country including in Malaysia. A sanitary landfill is an engineered means of disposing waste. It is a site where solid wastes are placed on or in the ground at a selected location by means of engineering design and techniques that minimize pollution of air, water and soil, and other risks to man and animals.

The sanitary landfill represented a dramatic improvement over the open dump. Controlled placement of waste in sanitary landfills greatly reduced the number of rodents and insects, dramatically reduced public health risks, and generally contributed to major aesthetic improvements in waste disposal [2]. Nearly decades the practice of sanitary landfill has developed into fully engineered facilities subjected to extensive environmental regulations.

An ever-expanding population and high rates of economic development in Malaysia resulted in the generation of large amount of waste. According to the statistic of Ministry of Housing and Local Government in year 2002, it is estimated about 17,000 tones of waste generated in Peninsular Malaysia and the average daily disposal rate generated was 0.85 kg/cap/day. With that, Malaysia is facing an increase in waste generation and followed by waste disposal problems.

Following the footsteps of developed countries and urbanization, the amount of waste produced rapidly increases; space for permanent disposal becomes critical. Because of increasing number of sanitary landfills, leachate treatment has become a major environmental concern, especially with regulatory agencies and environment authority. In fact, leachate consists of water and water-soluble compounds in the refuse that accumulate as water moves through the landfill. This water may be formed from rainfall or from the waste itself.

Hence, if the solid waste is not managed well, it may present some negative impacts. For instance, leachate, entering the river system, catchment areas, nearby surface

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and ground water possess potential negative effects on the water quality. Therefore, strict leachate control measures are required in order to prevent the groundwater pollution. Before 1970s, the engineered liners for landfill were not fully practiced. Under the 1991 Subtitle D rules promulgated by (Environmental Protection Agency (EPA), new landfills must be lined in a specific manner or meet maximum contaminant levels for the groundwater at the landfill boundary [3].

In modern landfills, the waste is contained by a liner system. The liner may be constructed of compacted clay or mixed materials, a prefabricated synthetic material, or a combination of the two. The linings to these cells generally consist of low permeability clays possibly in combination with a synthetic liners or liners. Material suitability relates to material type and its potential to form a barrier of suitable low permeability. A landfill liner supposes to be a low permeable barrier. Meanwhile, landfill liners are designed and constructed to create a barrier between the waste and the environment and to drain the leachate to collection and treatment facilities. This is done to prevent the uncontrolled release of leachate into the environment.

The objectives of this study are to determine the natural soil characteristics and its chemical compositions at Endau-Rompin National Park can be used and acceptable for a compacted soil liner limit.

2. Material and Method

2.1 Location of Samples

This National Park is a protected tropical rainforest in Malaysia with rock formation dating back some 248 million years; Endau Rompin National Park (Fig.1) is mostly hilly with some prominent sandstone highland. It is also to be a watershed of several rivers such as Endau River, Selai, and Jasin River.The natural soil samples were taken from Endau Rompin National Park (PETA), Johor. There are two specific areas for the soil samples i.e. at Kampung Peta (KP) and Nature Education and Research Centre (NERC). Fig. 2 shows the location of the soil samples.

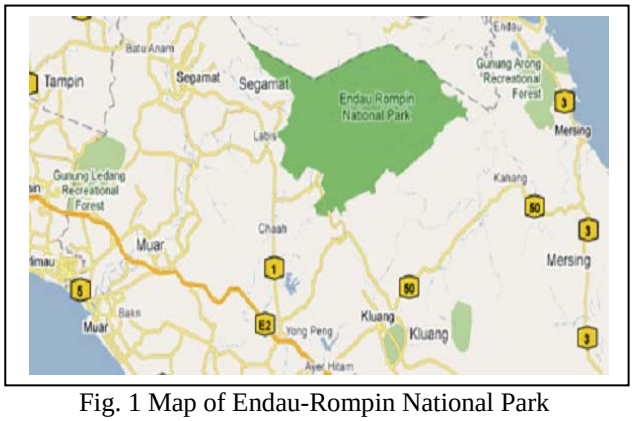

Fig. 1 Map of Endau-Rompin National Park

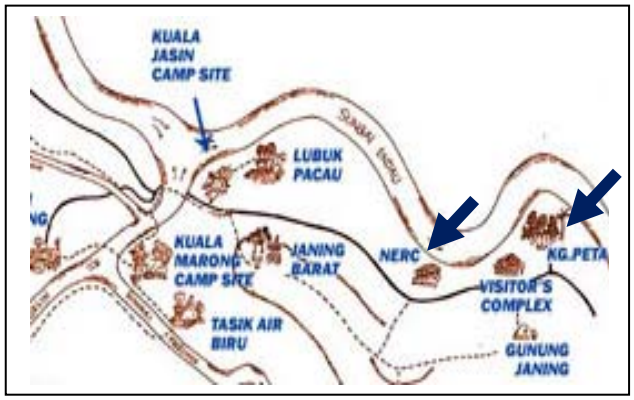

Fig. 2 Location of Soil Samples (Endau-Rompin National Park)

2.2 Analytical methods

Laboratory experiments were carried out in Geotechnical and Environmental Analysis Laboratory, University of Tun Hussein Onn Malaysia (UTHM). Soil tests were carried out to determine particle size, Atterberg limits, and specific gravity. All the tests were conducted according to the British Standard BS: 1377:1990. Chemical compositions of soil samples were tested using X-Ray Fluorescence (XRF) device (Bruker AXS: S4 PIONEER). The pH was conducted using pH meter (EUTECH: pH 1589).

3. Results and Discussion

Table 1 shows that results of particle size for Kampung Peta (KP) and NERC soil samples. From the result, the particle size is fulfilling the criteria which suggest by Daniel [2]. KP and NERC soil are suitable to be used as a compacted soil liner for sanitary landfill. KP soils reveal better than NERC soil because the KP soils contain more silt and clay particle. The silt and clay soils for KP were up to 79.4%, while for NERC only 32.7%.

Table 1 Result of Particle Size Tests

Soil Type	KP	NERC
Gravel (%)	0.6	1.3
Sand (%)	20.0	66.0
Silt and Clay (%)	79.4	32.7
Clay (%)	6.9	2.7

Table 2 shows the Atterberg Limits for KP and NERC soils were tested by using Cone Penetration method. Liquid limits (LL) for KP and NERC are 52.0% and 36.5% respectively. The LLs are met the criterion that suggested by NRA [5]. Plasticity Index for both soils reveal 28.64 for KP and 16.21 for NECR. The PI values are in the limits that were suggested by Daniel (PI > 7%) [2], Murray (PI > 12%) [6], Gorndon (PI > 15%) [7], and Willian (PI > 15)[8]. Activity (A) for KP and NERC are 4.16 and 6.0 respectively. The values are met the criterion that was recommended by DOE (A > 0.3) [4].

The KP soils can be classified as inorganic clay of high plasticity (CH) and the NERC as very clayey sand (SC).

Table 2 Atterberg Limits

Soil Properties	KP	NERC
Liquid Limit, LL (%)	52.0	36.5
Plastic Limit, PL (%)	23.36	20.29
Plasticity Index, PI (%)	28.64	16.21
Activity	4.16	6.0
Soil Classification	CH	SC

Two soil samples were analyzed for major chemical elements by using X-Ray Fluorescence test (XRF). Results are shown in Table 3.

Table 3 Data of chemical composition of soil

Elements	Concentration (%)	
	KP	NERC
SiO_2	56.30	69.80
Al_2O_3	27.80	23.20
Fe_2O_3	12.60	5.00
TiO_2	2.20	1.25
K_2O	0.43	0.32
S	0<LLD*	-
Mg	0<LLD	-
Zr	0<LLD	0<LLD

*LLD = Low Limit of Detection

As both soil samples also consists high content of Silicon Dioxide (SiO_2). The SiO_2 at NERC soil is higher than KP soils. The SiO_2, also known as silica that is most commonly found in nature as sand or quartz. Therefore, the NERC soils are more sands compared to KP soils. For KP soil samples are low limit of detection of Sulphur (S) and Magnesium (Mg), also same as NERC soil samples that have no this two chemical compositions. And both of the soil samples are also low limit of detection of Zirconium (Zr). At KP for elements of Al_2O_3, Fe_2O_3, TiO_2, and K_2O are 27.8%, 12.6%, 2.2%, 0.43 respectively. NERC, its chemical compositions for Al_2O_3, Fe_2O_3, TiO_2, and K_2O are 23.2%, 5.0%, 1.25, 0.32% respectively. The average of pH KP and NERC soil sample are 6.86 and 6.83 respectively. Both of the soils reveal the pH of a neutral zone.

4. Conclusion

In selecting and approving soils for landfill sites, the definitions 'material suitability' and acceptability of materials' are useful in the distinction between source materials for possible use as a liner. As a conclusion, both locations i.e. Kampung Peta (KP) and Nature Education and Research Centre (NERC), Endau Rompin National Park (PETA), Johor, their soils are suitable to be used as a compacted soil liner for sanitary landfill. According to the natural soils properties test, the KP soils are classified as an inorganic clay of high plasticity (CH) with higher silt and clay contents, hgher plastic limit, higher plasticity index. And NERC soils are classified as very clayey sand (SC) with higher Silicon Dioxide (SiO_2).

References

[1] Bagchi A. Design of Landfills and Integrated Solid Waste Management. New Jersey: John Wiley, (2004), pp 239.
[2] Daniel D. E. Geotechnical Practice for Waste Disposal. London: Chapman and Hall, (1993), pp. 139-140.
[3] Davis M. L., and Cornwell D. A. Introduction to Environmental Engineering 4th. ed. New York: Mc Graw Hill, (2008), pp 762-783.
[4] Department Of Environment (DOE). Waste Management Paper 26B – Landfill Design, Construction and Operational Practice. HMSO,London, (1995a).
[5] NRA .Policy and Practice for the Protection of Groundwaters. National Rivers Authority, Bristol. (1992).
[6] Murray E. J., Dixon N., and Jones D. R. V. Properties and Testing of Clay Liners. London: Thomas Telford, (1998), pp37-49.
[7] Gordon, M. E. Design and Performance Monitoring of Clay-lined Landfills. Geotechnical Special Publication No.13, (1987), ASCE, pp. 500-514.
[8] Williams, C. E. Containment Applications for Earthen Liners. In Proceedings of the 1987 Speciality conference on Environmental Engineering. Ed. Dietz, J. D., ASCE, (1987), 122-128.
[9] NWWRO. Earthworks on Landfill Sites – A Technical Note on the Design, Construction and Quality Assurance of Compacted Clay Liners. Document No. NWTECH.002, (1996).