THE SUITABILITY OF THE VOLCANIC SOIL FOUND IN GRIK, TO BE USED AS A LANDFILL LINER.

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CIVIL ENGINEERING
UNIVERSITI TEKNOLOGI PETRONAS
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By

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Dissertation submitted in partial fulfillment of
the requirements for the
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Approved By:

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(Assoc. Prof. Dr. Nasiman Sapari)

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TRONOH, PERAK
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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the reference and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

H Madalana.

Madalana Mashoto Harriet

ABSTRACT

This project presents the analysis of the volcanic clay soil from Grik, Perak, the study of its characteristics and its suitability to be used as a landfill liner.

A landfill is an engineered method for land disposal of solid or hazardous wastes in a manner that protects the environment. Within the landfill biological, chemical, and physical processes occur that promote the degradation of wastes and result in the production of leachate and gases. And thus, a landfill design and construction must include elements that permit control of this leachate/pollutant and gas. The major design amongst other parameters will include the design of a liner.

This liner should be strong and be able to prevent any penetration to the ground water so not to contaminate the ground, thus, it should also be a good pollutant absorber. Should it be a particular clay liner, then such characteristics should be possessed by it.
The problem with the ordinary liners such as the geosynthetic liners is that it may permeable and it doesn't last for a long period before it deteriorates. This is the problem that this study / research is trying to solve in coming up with a better landfill liner.

The methodology of this project involves testing on the hydraulic conductivity of the clay, analysis of the XRF and AXRD and also a test on the adsorption of pollutants by the clay. All these where carefully analyzed so as to see if the clay is suitable to be used as a landfill liner. The hydraulic conductivity of the clay is the most crucial / primary requirement for a clay liner , and in this case it proved to be so small, and thus meeting the requirement of a liner according to the European Union standards on land filling of waste products .

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Last but not least , to my Beloved family : I was able to do all this things because I know I have your unconditional love and full support in all that I do. Thank you.

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CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

1.1 Background of Study

This thesis presents the findings of a study about the suitability of clay soil originated from volcanic rock for a landfill liner. So it specifically deals with clay to be used as a liner for landfill.

Landfill

A landfill is a carefully engineered depression in the ground (or built on top of the ground, resembling a football stadium) into which wastes are put. The most commonly known types of landfills are the Municipal Solid Waste (MSW) landfills. A MSW landfill must be designed and constructed to accept highly variable waste stream .A solid waste landfill must be able to prevent ground-water pollution, collect leachate, permit gas venting and provide groundwater and gas monitoring (Qian et al, 2002). This report focuses more on the invention of a liner than can perform such objectives.

Liner system

The clay liner system is placed at the bottom and lateral sides of a landfill. The liner system acts as a barrier against the advective (hydraulic) and diffusive transport of leachate solutes. Its main purpose is to isolate the solid waste and prevent contamination of the surrounding soil and ground water. A liner consists of multiple barrier and drainage layers. The barrier may consist of compacted clay liner or a geosynthetic liner and / or a combination of both (Qian et al, 2002).

1.2 Problem Statement

Many landfills in Malaysia are not provided with liners, and those kinds of landfills without liners are most likely to experience the problem of leachate penetration and thus contaminating the ground water .Furthermore, most landfill liners today are made of a tough plastic film called high density polyethylene (HDPE). A number of household chemicals will degrade HDPE, permeating it (passing though it), making it lose its strength, softening it, or making it become brittle and crack. Not only will household chemicals, such as moth balls, degrade HDPE, but much more benign things can cause it to develop stress cracks, such as, margarine, vinegar, ethyl alcohol (booze), shoe polish, peppermint oil, to name a few(Rachel, H 2002).This is not the only thing , the HPDE liners are quite expensive.

Problems related to landfill pollution are due to the amount of organic compounds in the waste which is microbially degraded, leading to soluble and volatile degradation products. It has been suggested that proper landfill management (e. g operational practices, controlling the waste type accepted for land filling, appropriate leachate treatment prior to discharge) might reduce problems associated with landfills. And thus, anywhere else in the world, including Malaysia, it would be of great advantage to present a liner, preferably a Clay liner that can minimize and omit all these problems.

Examples of: Clay liners and High density polyethylene (HDPE) liners.

Clay liner HDPE liner

1.3 Objective of the Study

The main objective is to test the suitability of the clay soil to be used as a liner for landfills.

1.4 Scope of Study

The scope of study focuses on finding a suitable landfill liner , one that can withstand any form of liquid passed on through it , such as Leachate - which is the liquid produced from waste and it is very dangerous and should it penetrate to the ground , it would pollute the ground water.

The *raison d'être* for a good solid waste management system is to improve public health and the preservation of the living environment as well as the preservation of the natural resources. In modern day integrated solid waste management system, it is a total system of waste management that ranges from collection of the generated waste stream , recycling which is encouraged , transportation of the wastes to transfer stations or directly to disposal sites and treatment. The aim is to minimize the risks of negative impacts on the environment at every stage in the system. This is possible if the foundation of it is good, and the foundation is the liners used on the landfill.

CHAPTER 2

2 LITERATURE REVIEW/ THEORY

2.1 Literature Review

In solid waste management, the need of land filling is very important. Failure to this might result to irreversible consequences that are disturbing and undesired either to man or to the environment.

Back in the days, landfills were put in convenient locations on the least expensive land. The waste was 'out of sight, out of mind'. People did not realize that as the waste rots and decomposes, it can release toxic chemicals. Meaning that, there was no need for liners, but this had negative impacts and also since it was producing of gases (methane and other gasses) to the air we breathe, it was harmful to both the animals and humans beings(Vesilind P et al,2002).

So, at the end of the day the need of these landfills is there. Though these landfills will create further problems if they are not carefully lined/ a bad liner is used instead. This will results to ground contamination and this is what we are trying to avoid. Thus, a good liner for landfill is definitely needed.

The clay from Grik is said to be a Montmorrilonite type of specie from the smectite group. These groups are said to have high Cation Exchange Capabilities (CEC), low in permeability and suitable to be used at landfill liners, hence, making this clay suitable to be used as a liner for the landfills. And to add on, it is a naturally occurring and readily available material in Malaysia. Thus it is an advantage to have such kind of clays (Qian X, 2002).

Montmorillonite clay is a very soft phyllosilicate mineral that typically forms in the microscopic crystals, forming clay. It is named after Montmorillon in France. Montmorrilonite, a member of the smectite family, is 2:1 clay, meaning that it has 2 tetrahedral sheets sandwiching a central octahedral sheet. The particles are plate-shaped with an average diameter of approximately 1 micrometer.

It is the main constituent of the volcanic ash weathering product, bentonite. Modern landfill liners in the United States as well as in many countries in the world are formed of bentonite clay types of liners. The objective is to prevent leachate that is produced in municipal solid waste and hazardous waste landfills from seeping through the ground and into the groundwater. This is necessary since once the groundwater is contaminated, it is extremely difficult to clean and render the water safe again from human use (Dana, 1892).

2.2 Cases of Landfill in Malaysia

Malaysia, one of the 'Asian tiger' economies, has enjoyed remarkable growth over the last few decades, with industrialization, agriculture and tourism playing leading roles in this success story. But today, despite a relatively positive environmental record, Malaysia faces major problems of waste disposal.

At present, the per capita generation of solid waste in Malaysia varies from 0.45 to 1.44 kg/day depending on the economic status of an area (Consumer's Association of Penang, 2001). In general, the per capita generation rate is about 1 kg/ day. Malaysian solid waste contains very high organic wastes and consequently high moisture content and bulk density of above 200 kg/ m^3. A recent study conducted in Kuala Lumpur has revealed that the amount of organic waste for residential area range from 62 to 72% (Consumer's Association of Penang, 2001). An average annual generation rate increase of 4 % is predicated (2.5 % attributed to population increase, 1.5 % due to increase of waste production per capita). Kuala Lumpur and Selangor produces 7,922 tons/day in 2000, and this will increase to 11, 728 tons / day in 2010. For the sate of Negeri Sembilan, Melaka and Johor, waste generated for 2000 was 2633 tons/day and 3539 tons/day are expected by 2015. It has been estimated that the average Klang Valley residents produced 1.56kg of garbage every day in 1998 (star, 2000) .So this concludes that, there is a strong need for proper landfills to be constructed and hence, for it to be worth it, it should be accompanied by a good clay liner. There are 230 landfills in Malaysia and all except a few are unsanitary in nature.

The generations of municipal solid waste (MSW) of states in Malaysia since 2000 are listed in Table 2.1

Table 2.1 Generation of MSW in Malaysia (source MHLG, 2003)

State	Year 2000		Year 2001		Year 2002	
	Population	solid waste generation (tonne/day)	Population	Solid waste Generation (tonne/ day)	Population	Solid waste Generation (tonne/day)
JOHOR	2,252,882	1,915	2,309,204	2,002	2,366,934	2,093
KEDAH	1,557,259	1,324	1,596,190	1,384	1,636,095	1,447
KELANTAN	1,216,769	1,034	1,247,188	1,081	1,278,368	1,131
MELAKA	605,361	515	620,495	538	636,007	562
NEG. SEMBILAN	890,597	757	912,862	791	935,683	827
PAHANG	1,126,000	957	1,154,150	1,001	1,183,004	1,046
PERAK	1,796,575	1,527	1,841,489	1,597	1,887,527	1,669
PERLIS	230,000	196	235,750	204	241,644	214
PULAU PINANG	1,279,470	1,088	1,311,457	1,137	1,344,243	1,189
SELANGOR	3,325,261	2,826	3,408,393	2,955	3,493,602	3,090
TERENGGANU	1,038,436	883	1,064,397	923	1,091,007	965
KUALA LUMPUR	1,400,000	2,520	1,435,000	2,635	1,470,875	2,755
TOTAL	**16,718,610**	**15,541**	**17,136,575**	**16,248**	**17,564,989**	**16,987**

This table helps better understand the status of Solid Management waste in Malaysia, provided by the Local Government Department Ministry of Housing and local Government.

- An ever-expanding population and high rates of economic development in Malaysia resulted in the generation of vast amount of waste.
- It is estimated about 17,000 tonne/day of waste generated in Peninsular Malaysia.

- Average per capita generation of waste 0.85 kg/cap/day.
- About 1.5 kg/cap/day in Kuala Lumpur of waste generation.
- About 76% of waste generated are collected.
- 1-2% is recycled and the remainder is taken to disposal sites.
- About 5% waste collected in KL is reused and recycled.
- Over 40% of 175 disposal sites are operating as dumpsite.
- Intermediate treatment is limited to small-scale thermal treatment plant in resorted islands.

We have three basic choices for handling or disposing of this waste: Bury it, Burn it and / or Recycle it / Reuse it. In the best of all possible worlds, we would attempt to minimize the amount of waste slated for burial or incineration by designing and implementing programs focused on waste reduction, recycling, and re-use. In spite of vigorous efforts in this direction during the past decade, up to 75 % of the nation's solid waste is still land filled. (Qian et al 2002).

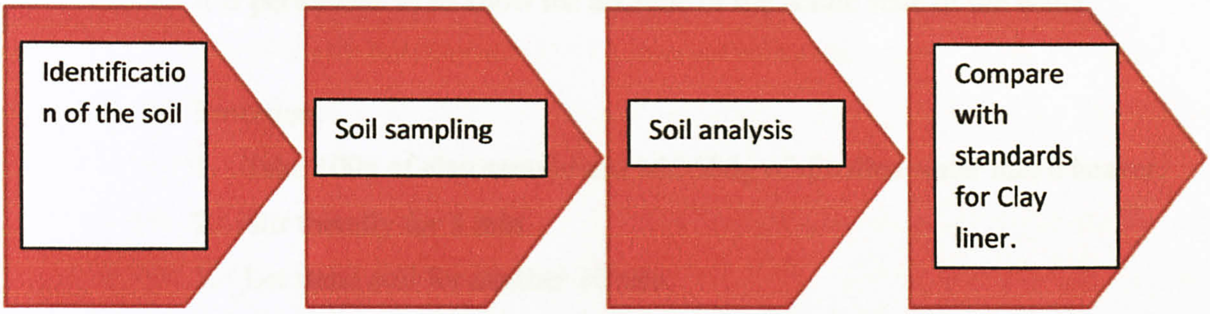
For Better or worse, the need for land filling of solid waste and a good liner to top in up will continue indefinitely for a number of reasons. Incineration is not a variable method of disposal for wide variety of wastes (e.g., mine and mill wastes and other inorganic noncombustible). Furthermore, incineration may lead to air pollution problems, and it creates ash residue that still must be landfilled. Recycling efforts eventually encounter practical limits that make further reductions in the waste stream that is slated for land disposal hard to achieve.

Landfill liners can either be plastic or clay. Amongst other types, these are the two most commonly used all over the world. The plastic kind of liners can be degradable, they are expensive and sometimes not so easily accessible (easy to find). Unlike with the Clay, they are not chemically degraded by the chemicals present in the leachate, can be easily accessed, for they are nature's product and are good landfill liners.

CHAPTER 3

METHODOLOGY

All the experiments were conducted so as to prove if the clay soil is suitable to be used as a landfill liner and also to see if it is a good pollutant absorber.



3.1 *THE SUITABILITY OF THE CLAY SOIL AS A LANDFILL LINER*

Table3.1 shows a DETAILED ANALYSIS of all the experiments that have been conducted.

Test	Objective to Determine	Apparatus
pH	To determine the acidity /alkalinity of the clay	Distilled water, shaker, and beaker and Ph meter.
Particle Density	The value of particle Density	Pyknometer,thermometer,electro balance, glass rod
Permeability Test	The coefficient of permeability	Permeameter cell, vertical adjustable reservoir tank, stops watched.
Particle size distribution	Determine the distribution of grain size.	Mechanical shaker and sieves and Hydrometer method using.
XRF	Identifies the elementary constituents of the Clay	XRF Machine
XRD	Identifies the Mineral constituents of the clay.	XRD Machine

pH

- general discussion

This is the easiest and less time consuming lab experiment that can be conducted. It is performed so to know the alkaline or the acidic state of the water.

- Procedure

1. Take 100g of clay sample and add 500g of distilled water into a beaker.
2. Stir therally for 5 min.
3. Let stand still for another 10 min
4. Measure the pH of the water then, using the pH meter.

Particle Density

- General discussion

Three methods are described to determine the particle density/specific gravity soil. Three types of methods are gas jar method, small pyknometer method and large pyknometer method. Gas jar method is suitable for most soils including those containing gravel-sized particles. Small pyknometer method we used for soils consisting of clay silt and sand-sized particles whereas the large pyknometer method is suitable for soils containing particles up to medium gravel size. For our case a small pyknometer method was used.

- Procedures

1. Take a sample of oven dried at 104^0C soil break down the course particles retained on a 20mm, use 400g from the sample for this experiment.
2. Clean and dry the pyknometer and weigh the whole assembly to the nearest 0.5g(m1)
3. Remove the screw top and transfer the first specimens from the container directly into the jar, weigh the jar and content g(m^2)
4. Add water to about half fill of the jar, stir the mixer thoroughly with the glass rod to remove air trapped in the soil. Fit the screw crap and tighten it is that the reference marks coincide, fill the pyknometer with water.
5. Leave the pyknometer standing for at least 42 hours at room temperature to allow air to escape and froth to disperse, top up pyknometer with water so that the water surface is flush with the hole in the conical cap. Make notes that air bubbles or froth are not trapped under the cap after drying the pyknometer weigh the whole to the nearest 0.5 g (m3).

Determination of particle size distribution

- General Discussion

  Two methods of sieving are specified. Wet sieving is the definitive method applicable to essentially cohesion less soils. Dry sieving is suitable only for soils containing insignificant quantities of silt and sand.

- Procedures

1. Weigh the oven dried sample to 0.1% to its total mass(m1)
2. Stack 8 numbers of test sieves on the mechanical shaker with the largest size test sieve appropriate to the bottom of the stack followed by the smaller size test sieves and a receiver at the bottom of the stack.
3. Place the sample on the top sieve and cover the sieve with a lid. Agitate the test sieves on the mechanical sieve shaker for 5 minutes. Weigh the amount retained on each of the test sieves to 0.1% of its total mass.

Hydrometer Method

- General discussion

Two methods for determining the size distribution of the fine particles namely the pipette method and the hydrometer method, in both of which the density of the soil suspension at various intervals is measured. A combined sieving and sedimentation procedure enables a continuous particle size distribution curve of a soil to be plotted from the size of the coarsest particle down to the clay size. This method covers the quantitative determination of the particle distribution in a soil from the coarse sand size to the clay size.

- Procedures

1. Transfer 50g of soil sample that passes the 63μm test sieve into a conical flask
2. Weigh 40g of sodium hexametaphosphate solution and add 1L of distill water to it. Insert the rubber bung and place this cylinder and mix it such that no crystal of sodium appears from the distilled water, keep it in constant temperature for more than an hour.
3. Transfer 10Ml of this sodium mixed solution into another cylinder, mix it with the 50g of soil sample passing 63μm test sieve that was weight before. Insert the stopper, mix the soil and sodium water solution up and down 60 times all in total in 2minutes so its vigorous mix.
4. After 1hour take the cylinder with the soil suspension is placed upright in the bath start the timer. Remove the rubber bungs carefully from the cylinder. Immerse the hydrometer in the suspension to a depth slightly below its floating position and allow it to float freely.
5. Take hydrometer reading at the upper rim of the meniscus after periods of 0.5min, 1min, 2min and 4min.Remove the hydrometer slowly rinse in distilled water and place it in the cylinder of distilled water with dispersion at the same temperature as the soil suspension. Observe and record the top of the meniscus reading, R0.

6. Reinsert thee hydrometer in the soil suspension and take and record readings after periods on 8min, 30min, 2h, 8h and 24h from the start of sedimentation, and twice during the following day if appropriate. Avoid vibration of sample, read the temperature to an accuracy of (+-) 0.50C.

Permeability using the falling head method.

- General discussion

The permeability of soil is a measure of its capacity to allow flow of water through the pore spaces between solid particles. The degree of permeability is determined by applying a hydraulic pressure gradient in sample of saturated soil and measuring the consequent rate of flow. The coefficient of permeability is expressed as a velocity.

- Procedures

1. Adjust the height of the inlet reservoir to a suitable level with regard to the hydraulic gradient to be imposed on the sample
2. Open the control valve at the base to produce flow through the sample under a hydraulic gradient appreciably less than unity. Allow the water levels in the manometer tubes to become stable before starting test measurements.
3. Record the levels of water in the manometer tubes and the time taken from one manometer reading to another.

- **Adsorption test**

- Collection of the clay soil sample.

The sample for this test was oven dried for a week, since it's a clay soil it would be hard to settle in a PVC cylinder without first drying it, because it would be sticky. Thus, it was first dried.

- Preparation of the sample

300g of this clay soil was used in the experiment together with another 100g of coarse soil.

- Testing of the clay soil sample

Experiment Design

The constants in this experiment were:

- The filter used
- Amount of pollutants (20 ml)
- Amount of soil filtered (300 mg) of clay and 100mg of coarse soil
- Number of trials on 1 soil type with 1 kind of pollutant (1)
- Temperature of pollutants (21°C)

The manipulated variable was the type of soil filtered and the kind of pollutant being filtered.

The responding variable was the amount of pollutants that filtered through the combined 400 mg of soil.

To measure the responding variable, a graduated cylinder in mL was used.

Materials

QUANTITY	ITEM DESCRIPTION
1	Plastic Filter
100mg, 300mg	coarse soil, Clay
20mL	Calcium Hydroxide
500mL	PVC Graduated Cylinder
2	Transparent Tubes
2	Organized stands
1	Measuring Tape

- Procedures

After completing the construction of the experiment as shown below, this is what was done.

1. A net (mosquito net) was placed as base on the PVC pipe.
2. Then 100g of coarse soil was put in.
3. Another net was placed above, keeping the coarse soil in between.
4. Clay soil of 300g was then inserted in.
5. Water was then let to go thru and up to the top of the pipe thru backward movement, this is done so to open the pores from the sand soil should there be any.
6. Then from this, water was allowed to pass thru the normal way, controlling the tube and taking necessary measurements of the Heights and lengths and any other parameters that were concerned.
7. One of the tubes was exiting to the cylinder where water was collected to see how good can the clay withhold the water / or how reluctant can it be to let water pass thru it.
8. Then the quantity of water collected from the cylinder was collected and measured / weighed.

See figure below for the construction of the experiment.

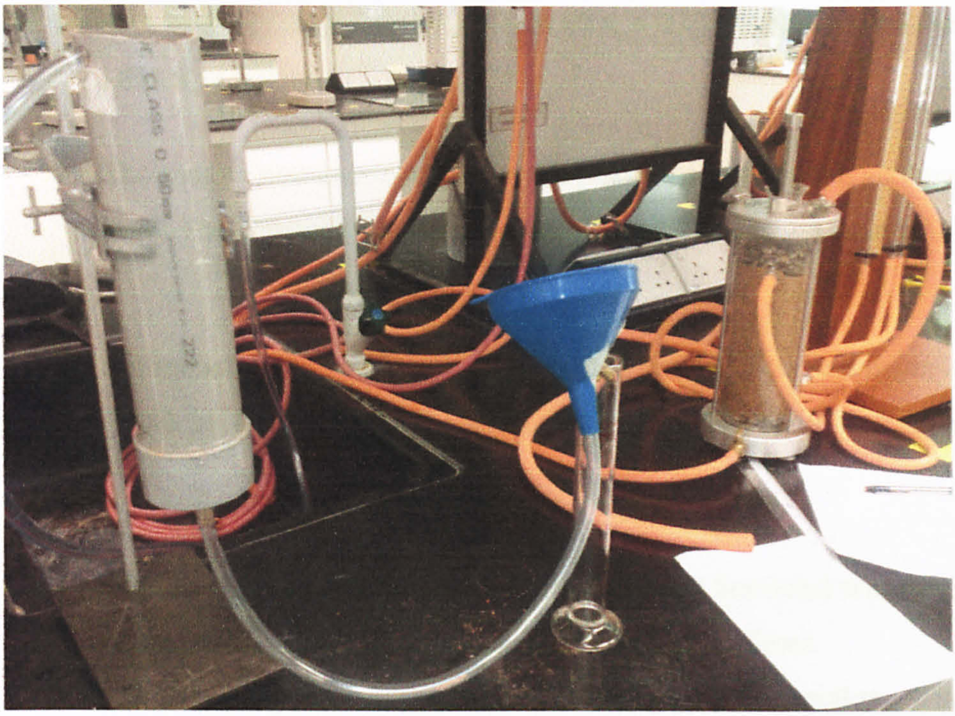


Figure 3.1: Showing the setting of the Column Experiment (permeability)

- X-RAY DIFFRACTION (XRD)

- PREPARATION OF SAMPLE

  - Take an oven dried clay sample to the XRD laboratory.
  - Three samples is recommended to go for testing , so that you can double check your results and be sure of what you have .
  - This is one of the heavy experiments, thus student are not allowed to do the tests themselves, a lab Technician gathers for this and He will just pass you the results.

➢ SAMPLE COLLECTION AND DATA ANALYSIS FOR A SINGLE CRYSTAL X-ray DIFFRACTION STUDIES

1. The sample was examined under the polarized microscope and mounted it on a magnetic head. The Crystal Wand to support the magnetic head is used while mounting the sample.

2. For mounting and centering of the sample, connection was made to the server computer (black background with the word: "Server" displayed in the middle).

3. Had to make sure that BIS (Bruker Instrument Services) was running on the server before doing anything. It had to be running at all times.
4. After the program launched select Instrument → Connection. The word "localhost" was typed in the text box and then clicked on "Connect". (You will have to wait while the computer communicates with the BIS software to set up the instrument. This usually takes 15 – 30 seconds. You will be connected when the connection window disappears).

5. Then the "*Simple Scans*" from the side bar was clicked. Then a window appeared in the main panel of the APEX2 window.

6. To center your crystal drive the goniometer to omega = -180 and phi = 0 deg (enter the angle values in the appropriate text boxes on the right hand side of the window and click on the "Drive" button just below them). To rotate your crystal 180 deg. Click on the "Phi + 90" button twice then on the drive button. Center your crystal as well as you can in this orientation, then rotate the crystal to phi = -90 or 90 deg by a single click of the "Phi +90" button. Center your crystal as well as you can in this orientation. Reiterate as necessary until you are satisfied that your sample is located along the phi-axis. Drive phi to 0 (zero) before continuing with the final height adjustment. With phi at zero, drive

omega to -30 deg. And adjust as necessary. DO NOT GO BEYOND OMEGA= -30 AS YOU WILL HAVE COLLISION.

7. Then on the Client computer, the matrix and data collection were started. (Double tap the "Scroll Lock" key).

8. Double clicked on the Start Database icon on the desktop and run the programmers

9. Within few minutes, in less than an hour approximately, the results came out in a graph form, which is also attached below, as results.

- PROCEDURE OF THE EXPERIMENT

1. Obtain a sample from your instructor, place it onto the double-side tape which is then placed on an aluminum sample holder; if you are preparing a powder sample, and use a spatula to spread the powder onto the double-side tape.
2. Read the instructions for the Miniflex X-ray diffract meter, which are on the wall above the instrument. Your instructor will explain the operation.
3. Set the instrument at optimum setting as follows

Time constant 2

range?

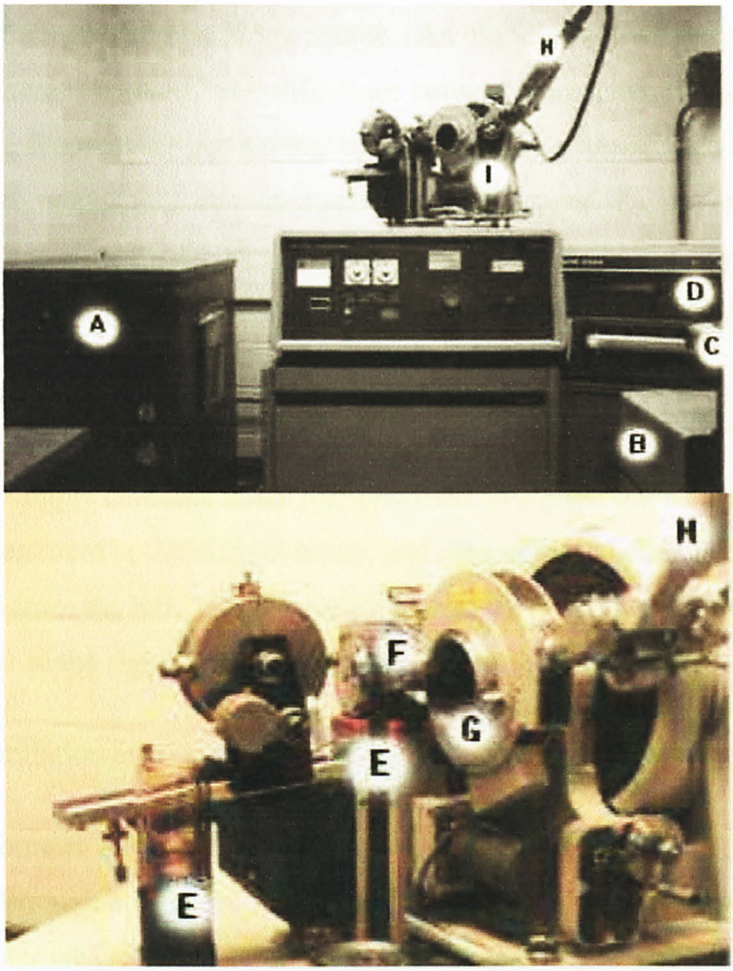
Chart speed: Low

4. Slide in the sample holder and adjust the beginning 2theta at 70 degree (It scans from high degrees to low degrees)
5. Switch on the start knob and chart recorder (slow) simultaneously, run your sample on slow chart speed.
6. Once scan gets down to 3 degree of 2theta, stop (switch start knob to off) and chart. TURN OFF X-ray.
7. Locate all peaks on the chart and corresponding 2theta values and write their values into the data chart below. Perform the necessary calculations in the table and calculate the repeat distance in your unit cell.

- PURPOSE OF TEST

Diffraction data has historically provided information regarding the structures of crystalline solids. Such data can be used to determine molecular structures, ranging from simple to complex, since the relative atomic positions of atoms can be determined. X-ray diffraction provided important evidence and indirect proof of atoms. Diffraction patterns constitute evidence for the periodically repeating arrangement of atoms in crystals. The symmetry of the diffraction patterns corresponds to the symmetry of the atomic packing. X-ray radiation directed at the solid provides the simplest way to determine the interatomic spacing that exists. The intensity of the diffracted beams also depends on the arrangement and atomic number of the atoms in the repeating motif, called the unit cell. Thus, the intensities of diffracted spots calculated for trial atomic positions can be compared with the experimental diffraction intensities to obtain the positions of the atoms themselves. From this as well as other indirect methods such as stoichiometric relationships and thermodynamics, evidence of atoms was obtained. However, a direct way to image atoms on the surfaces of materials now exists. Developed in the mid-1980, the scanning tunneling microscope (STM) permits direct imaging of atoms.

➢ THE EQUIPMENT USED



The diffract meter in the IPFW Geosciences Department. It consists of several parts.

A. The chiller provides a source of clean water to cool the X-ray tube.

B. The regulator smoothes our building current to provide a steady and dependable source of electricity to the diffract meter and its peripherals.

C. The computer sends commands to the diffract meter and records the output from an analysis. We are currently using a 486-100 running DR-DOS7 to run the diffract meter, and provide interfacing with this web page. We process most of the information digitally, although we can make hardcopy analog patterns directly on the;

D. Strip-chart recorder.

E. The tube provides an X-ray source. (An old tube, shown upside down, is on the counter top.) Inside there is a 40,000 volt difference between a tungsten filament and copper target. Electrons from the filament are accelerated by this voltage difference and hit the copper target with enough energy to produce the characteristic X-rays of copper. We use one part of the copper spectrum (with a wavelength of 1.54 angstrom) to make the diffraction pattern. The radiation is monochromatized by a graphite crystal mounted just ahead of the scintillation counter.

F. The theta compensating slit collimates the X-rays before they reach the sample.

G. The sample chamber holds the specimen. We grind our samples to a fine powder before mounting them in the diffract meter, and then close the chamber to allow the collimated X-rays to enter from the left. The X-rays hit and scatter from the sample. The diffracted beams leave the chamber to the right where they can be detected by the;

H. Scintillation counter which measures the X-ray intensity. It is mounted on the;

I. Goniometer which literally means angle-measuring device. The goniometer is motorized and moves through a range of 2-theta angles. Because the scintillation counter is connected to the goniomter we can measure the X-ray intensity at any angle to the specimen.

- X – RAY FLOURESENSE (XRF)

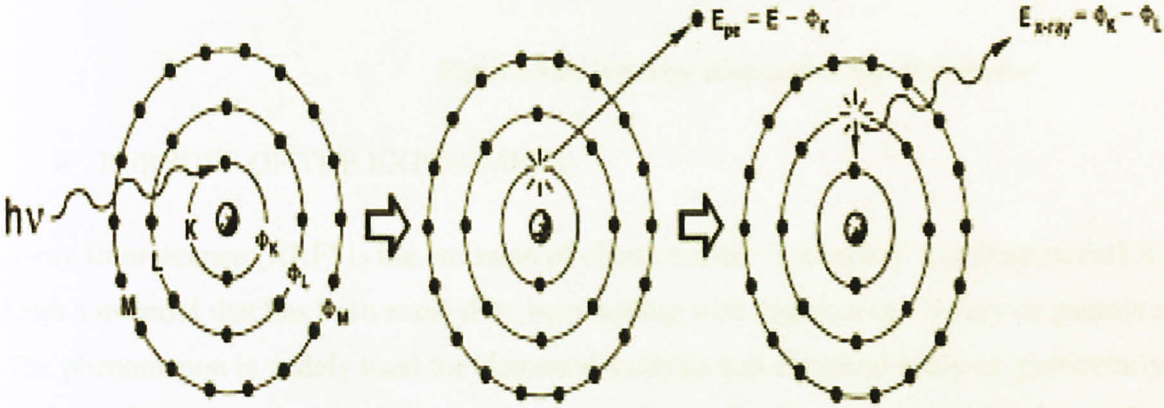
- PREPARATION OF THE SAMPLE

No spectacular preparations required. Just oven dry the sample and take 100g of it for testing.

- PROCEDURE OF EXPERIMENT

High energy photons (x-rays) displace inner shell electrons. Outer shell electrons then fall into the vacancy left by the displaced electron. In doing so, they normally emit light (fluoresce) equivalent the two states. Since each element has electron with more or less unique energy levels, the wavelength of light emitted is characteristic of the element. And the intensity of light emitted is proportional to the element concentration.

XRF
Process



There are generally two types of XRF spectrometers: wavelength dispersive and energy dispersive wavelength system uses a diffraction crystal to focus specific wavelengths onto a detector. A wavelength range is scanned by changing the angle in which the x-rays strike the crystal. An energy dispersive spectrometer shown in figure 2 below focuses all the emitted x-rays onto an energy analyzing detector. While this is faster and less expensive, wavelength dispersive spectrometers are more expensive and more sensitive and have higher resolution.

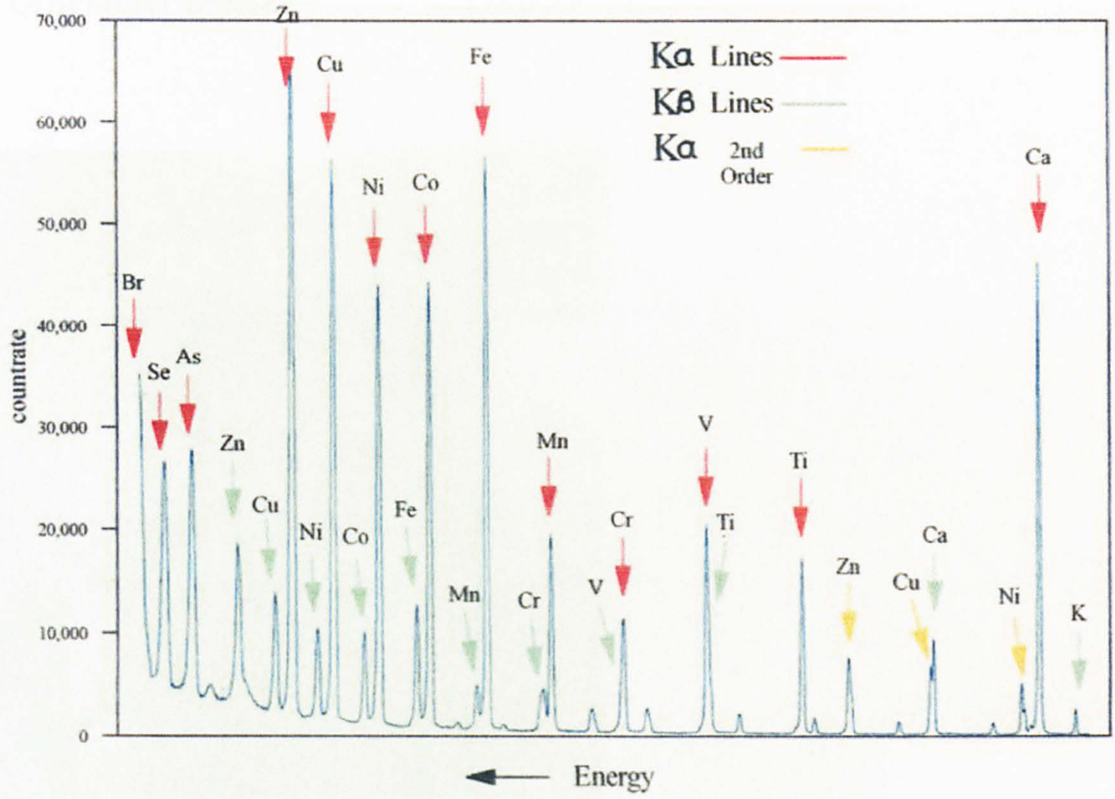


Figure 3.2: energy dispersive Spectrometer

- PURPOSE OF THE EXPERIMENT

X-ray fluorescence (XRF) is the emission of characteristic "secondary" (or fluorescent) X-rays from a material that has been excited by bombarding with high-energy X-rays or gamma rays. The phenomenon is widely used for elemental analysis and chemical analysis, particularly in the investigation of metals, glass, ceramics and building materials, and for research in geochemistry, forensic science and archaeology.

It basically shows the mineral constituents in the clay.

- EQUIPMENT USED

Figure 3.3: XRF equipment

CHAPTER 4

RESULTS AND DISCUSSION

1.

- Test Name : pH
- Results: At a temperature of 25.6 degrees Celsius, the pH of the water was found to be 5. 293.
- Discussion: The clay is acidic and this is the case with Malaysian soil, so this is acceptable and in the normal range for soil in this case.

2.

- Test name : Particle Density
- Results :
- Results: Calculations of the particle density are provided in the table below, with all the masses recorded in grams.

Table 4.1: Particle Density Test

Particle density test	Units	Quantity
initial mass of soil	g	400
mass of Jar+jar glass+plate+water(m3)	g	1792.25
mass of Jar+jar glass+plate+soil(m2)	g	938.3
mass of jar+gas jar+plate+water(m4)	g	1532.6
mass of jar+gas jar+plate (m1)	g	536.7
mass of soil (m2-m1)	g	401.6
mass of water in full jar (m4-m1)	g	995.9
mass of water used (m3-m2)	g	853.95
Volume of soil particles=(m4-m1)-(m3-m2)	ML	162.7
Particle density Ps=(m2-m1)/(m4-m1)-(m3-m1)	Mg/m^3	2.83
Average value ps	Mg/m^3	2.83

- Discussion : The specific gravity was calculated and it was found to be 2.83 Mg/m^3 which is an acceptable value since it falls within the range of 2-2.9.The specific gravity should be remembered since it will be required for some upcoming calculation from other experiments.

3.

- Name of Test : Determination of particle size distribution

- Results: the collected clay from the pan, meaning the passing clay through the sieve was calculated to be 499.95g.

- Discussion: There is no much difference in the initial mass used that is 500 g and ΣM=499.95g and since it is so minor, it can be neglected – this is die to some looses while the experiment was being conducted. The graphs of the results from the table are represented from a semi log graph that is provided according to the British standard test sieves. From the graph observations were made that the graph does not connect to zero due to missing values after the 63μm sieve.

The hydrometer experiment will complete these missing values. Sorting coefficient – uniformity is generally encountered in geologic works. And thus the hydrometer test was conducted.

4.

- Name of the test : Hydrometer Test
- Results :

Table 4.2 Hydrometer test

CALIBRATION AND SAMPLE DATA	
Meniscus correction(cm)	0.005
Reading in dispersant (Ro') 4min	1004
Dry mass of soil(g)	50
Viscosity of water at 23.3°C η	0.88
Particle density p_s	2.83

WHERE:

H(mm) =	71.64
V_h(g)=	66.1
h(mm) =	151.38
L(mm)=	312
C_m(mm)	0.0005

Table 4.3: Parameter values for the Hydrometer Test

Time elapsed t (min)	Temp ^{o}c	Reading R_h'	C_m	$R_h'+C_m=R_h$	Effective depth H_r(mm)	Particle diameter D(mm)	$R'_h-R_o'=R_d$	Percentage finer than D ,K%
0.5	24.2	1031	0.0005	1031.001	992.117	2.742168	27	84
1	24.2	1030	0.0005	1030.001	991.117	1.369754	26	80
2	24.2	1029	0.0005	1029.001	990.117	0.684212	25	77
4	24.2	1027	0.0005	1027.001	988.117	0.341441	23	71
8	24.2	1026	0.0005	1026.001	987.117	0.170554	22	68
30	24.2	1023	0.0005	1023.001	984.117	0.045348	19	59
120	24.2	1015	0.0005	1015.001	976.117	0.011248	11	34
480	24.2	1009	0.0005	1009.001	970.117	0.002795	5	15
1440	24.2	1006	0.0005	1006.001	967.117	0.000929	2	6

Table 4.4: Relationship between Hr (mm) and Rh (mm)

Rh(mm)	Hr(mm)
1031	992.117
1030	991.117
1029	990.117
1027	988.117
1026	987.117
1023	984.117
1015	976.117
1009	970.117
1006	967.117

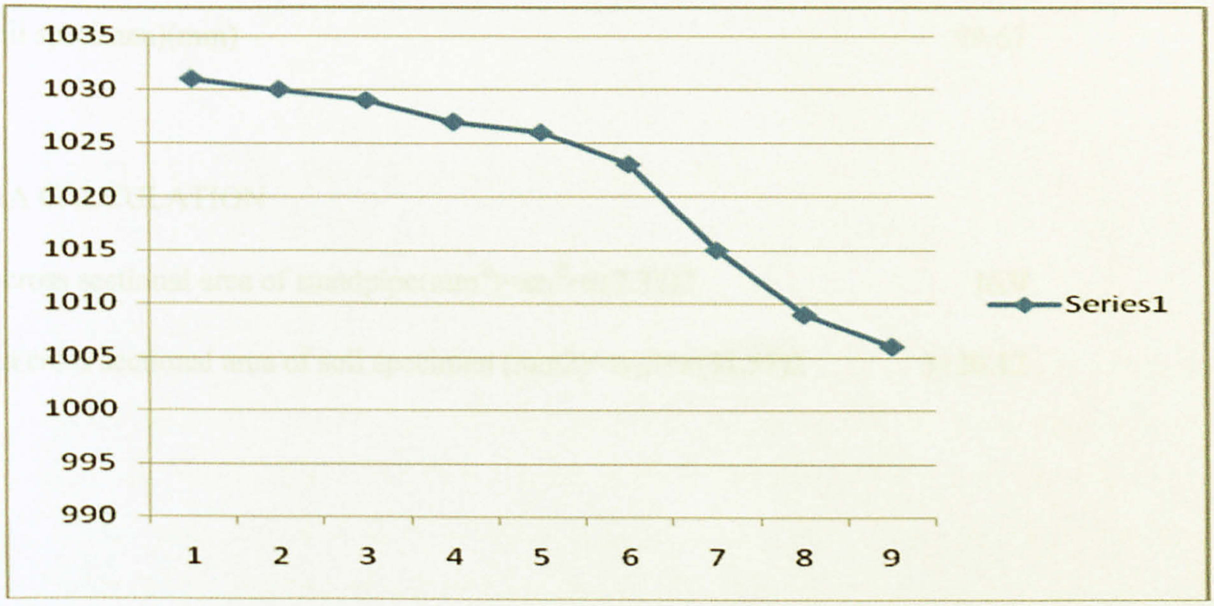


Figure 4.1: Relationship between H_r (mm) Vs R_h(mm)

- Discussion : An object that is denser than a liquid will sink in that liquid and an object that is less dense than a liquid will float in it. The hydrometer will sink lower in less dense liquids than in more dense liquids. The particles in less dense solutions are not as tightly packed as the particles in more dense. More dense liquids have more particles in the same volume to help push the hydrometer up than less dense liquids.

5.

- Name of test : Permeability using the falling head method.
- Results :

h_1(initial head at time t=0)	70
h_2(initial head at time t=0)	20
Q(ml)	18
t(s)	47
d_1(standpipe)(mm)	4.64
d_2(soil specimen)(mm)	63.13
L (soil specimen)(mm)	99.67

AREA CALCULATION

A is cross sectional area of standpipe(mm^2)=πr_1^2=π(2.32)2	16.9
A is a cross sectional area of soil specimen (mm2)=$\pi r_2 2$=π(31.57)2	3130.12

Using the equation K = QL / Aht

= 18 * 99.57 / (3130.12 * 50 * 47)

= 2.44* 10 $^{-4}$ mm / sec

= 2.44 * 10 $^{-5}$ cm / sec

Then using the equation below (W.Day ,1999):

$$k_{20^o C} = \left(\frac{\eta_{T^o C}}{\eta_{20^o C}} \right) k_{T_o C}$$

t=24 ---- room temperature

the viscosity at t = 24 = 0.9097

and thus :

K_{20}°C=2.219 * 10 $^{-5}$ = this is equivalent to the void size of the material.

- Discussion : Soils that contain more fine ,such as clay , such as in this case will have lowest hydraulic conductivity (W.Day,1999).This might be due the small drainage path that clay materials provide, with a result of large resistant of flow. Clay materials have fewer voids making it hard for water to flow through them. They have high cohesive force due to the arrangements of the particles.

This is close to the maximum permeability of a good landfill liner = 1 * 10 $^{-7}$, and thus, It can be concluded that clay can be used as a good landfill liner, for it meets the required standards in terms of hydraulic conductivity.

6.

- Name of the test : Column Experiment
- Results : The original purpose of this experiment was to determine how absorbent the clay soil of the pollutant is. The results of the experiment were that the clay soil consumed all the water and it was very hard to collect it from the cylinder, in one day, there was nothing to be collected and in a period of 4 days, then there was at least 2.5 ml of water that penetrated through the clay soil.
- Discusssion : This simply tells us that the clay soil is a good absorber , either of just liquid, i.e. leachate in landfills or simply of pollutants (like that one added) and if this is the case , then it is a good landfill liner because then it won't be so easy for the leachate and other pollutants to penetrate thru the clay layer into the ground , and by so, the problem of ground contamination will be highly reduced .ground water treatment is crucial and very expensive , so in any way that we can avoid contaminating the ground water , then it will be of much help.

7.

- Name of the test : XRF
- Results : Printed by Eval on 05 –March – 2009 16:29:19

Sample 1

Sample measured on the same day.

Chemical elements contained in this type of clay are:

Table 4.5: The elemental composition of the Clay from Grik

ELEMENT	PERCENTAGE	ELEMENT	PERCENTAGE
O	47.5 %	Ti	0.351%
Mg	0.474%	Mn	0.0691%
Al	8.78%	Fe	3.10%
Si	31.2%	Zn	0.00318%
P	7.55%	Rb	0.0378%
K	0.301%	Y	0.0194%
Ca	0.301%	Zr	0.0443%

Kindly refer to Appendix No. 2 for further understanding.

- Discussion: Oxygen, Silicon, Aluminum and Potassium are the most dominant elements present in this clay soil, with percentages of 47.5%, 31.2 %, 8.78 % and 7.55% respectively.
- From here the percentage specific species were calculated and compared with the compositions of Montmorrilonite to see if there is a match. The results show good match with the Montmorillonite specie. This specie is calculated from the equation $(0.5\ Ca, Na)_{0.66}(Al, Mg)_4[Si_8O_{20}]\ (OH)_4 * n\ H_20$ assuming n = 1
- **Table 4.6: Matching of the elemental composition**

Chemical Name	Atomic weights	A.W following the element	True % composition	% composition from clay	Matching?
$0.5\ Ca_{0.66}$	40.08	13.23	1.8	0.3	
Al_4	26.98	107.92	14	8.73	
Si_8	28.09	224.72	**30**	**31.2**	Yes
O_{25}	16.00	400	**53**	**48**	Yes
H_6	1.00	6	0.8	0	
TOTAL		751.87			

8.

- Name of Experiment : XRD
- Results : After the sample has been send to the XRD experiment, this is how the results came out and the graph looked like:

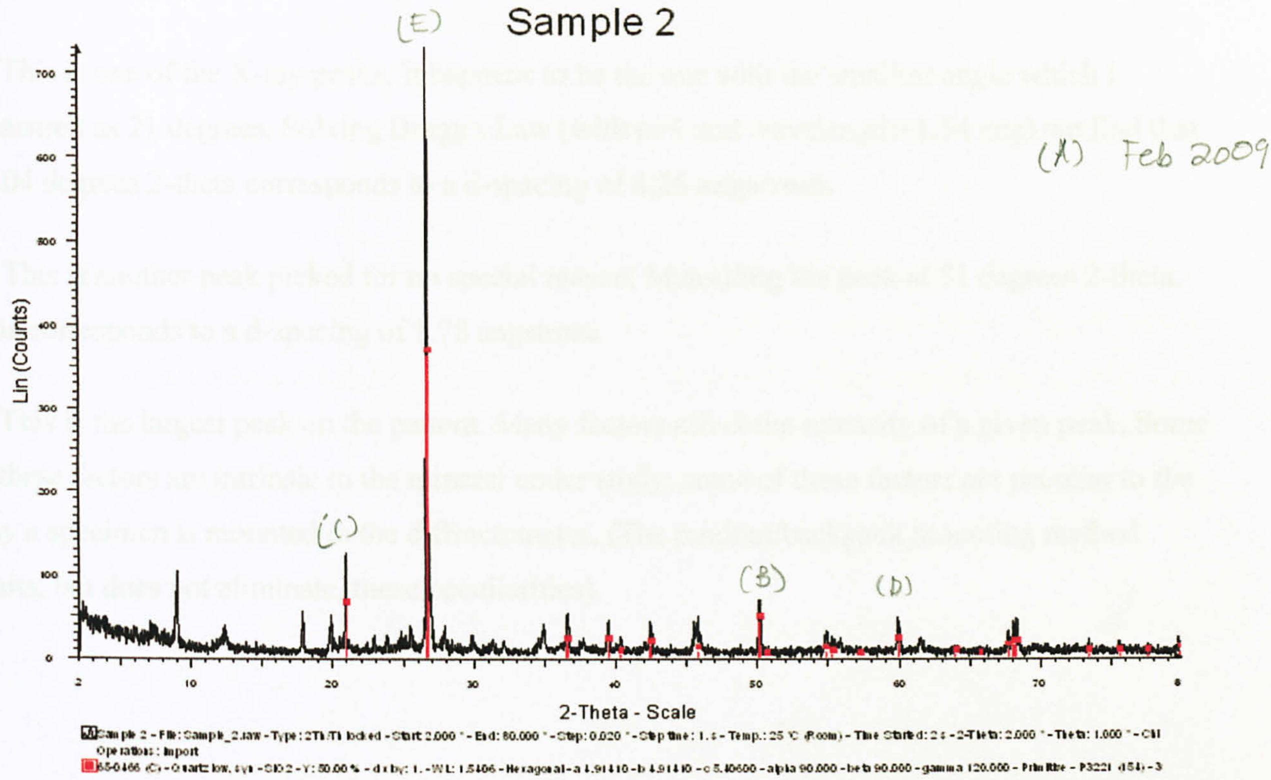


Figure 4.2: XRD graphical representation

- Discussion : Consider the following areas on the diffractogram.

A. The diffraction pattern is labeled with the sample name and other information pertinent to the experiment. The sample was randomly mounted using the backpack technique. The diffraction pattern was prepared on FEBRUARY 25TH 2009.

The diffractometer was running at 40 kV and 30 ma. Steps were in increments of 0.005 degrees, and counts were collected for 0.25 seconds at each step. The data were smoothed with a 15-pt (weighted, moving average) filter.

B. The vertical axis records X-ray intensity. The horizontal axis records angles in degrees 2-theta. Low angles (large d-spacing) lie to the right.

C. This is one of the X-ray peaks. It happens to be the one with the smallest angle which I measured as 21 degrees. Solving Bragg's Law (with n=1 and wavelength=1.54 ang) we find that 23.04 degrees 2-theta corresponds to a d-spacing of **4.26 angstrom.**

D. This is another peak picked for no special reason. Measuring the peak at 51 degrees 2-theta. This corresponds to a d-spacing of 1.78 angstrom.

E. This is the largest peak on the pattern. Many factors affect the intensity of a given peak. Some of these factors are intrinsic to the mineral under study; some of these factors are peculiar to the way a specimen is mounted in the diffractometer. (The random/backpack mounting method limits, but does not eliminate, these peculiarities).

CHAPTER 5

SUMMARY AND CONCLUSION

Clay liners at the bottom of landfill play a very important part in the whole multi barrier system for retaining pollutants. Porosity of this clay particle is above 70% and permeability (K) value of clay was found to be less than 10^{-7} cm/s and so the rate of advection transport through the clay is very low and in this case negligible. Clay has the property of swelling, plasticity, cohesion and adhesion. Some clay soils have the ability to act as membrane that restricts the passage of charged solutes.

Result from the column experiment (permeability) show that the clay has very low permeability It took 2 days to accumulate just 25ml of water back into the container that means that the water was trapped in the clay and could only flow slowly. This water had some chemicals ions (assumed to me the pollutants) in it. The K value was then calculated, using the same way as that way done to calculate for the permeability while testing parameters for the landfill liner, and thus it was found to be 2.25* $10^{-7,}$ which means its penetration ability is very low.

Results from the XRF analysis with reference from the XRD experiment show that the clay falls under the SMECTITE GROUP. It can either be Montmorillonite which is given by :
$(0.5\ Ca, Na)_{0.66}(Al, Mg)_4[Si_8O_{20}](OH)_4 * n\ H_20$ or Saponite which is given by :
$(0.5Ca, Na)_{0.66}Mg_6[(Si, Al)_8O_{20}](OH)_4 * nH_20$.

Both this species gave outcome close to that of the clay's main constituents, which is the Oxygen (48%) and the Silicon (31.2 %) both making about almost 80 % of the whole clay. Looking at the two, the clay was closely matching with the Montmorillonite

For solid waste the future brings about a large emphasis on resource recovery and solid waste reduction. Even though there will be less landfills in the future they will still play a major role in solid waste and residual disposal. Each year the design of the landfills and leachate control strategies will become more and more strict in order to protect the groundwater. So when the permit application is submitted by the municipality to the state, these applications will be looked at very closely to be sure the design engineer has properly designed the landfill. Designing a landfill requires proper application of the liner system, and there are other issues as well, such as proper slopes for runoff, and the fact that there has to be a sophisticated monitoring well system around the landfill, and most important the leachate must receive proper treatment before discharge. Under Subtitle D of RCRA all of these regulations are mandated and inforced through each state to ensure the safety of the soil and groundwater to be free from any solid waste contaminants (Yack, J., & O'Neill, E.J., 1996).

The tested clay materials, meets the requirements and therefore, with that the conclusion can be finally made that, the Volcanic clay soil from Grik, Perak, can be used as a landfill liner.

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APPENDIX

1. Soil Type and Particle Densities

SOIL TYPE	PARTICLE DENSITIES , Gs
Quartz Sand	2.64 – 2.66
Silt	2.67 – 2.73
Clay	2.70 – 2.90
Chalk	2.60 – 2.75
Loess	2.65 – 2.73
Peat	1.30 – 1.90

2. Detailed information of the XRF results

O	Mg	Al	Si	P	K	Ca
	2.3 KCps	54.3 KCps	224.3 KCps	2.7KCps	131.8 KCps	4.8 KCps
47.5 %	0.474%	8.78%	31.2%	0.399%	7.55%	0.301%

Ti	Mn	Fe	Zn	Rb	Y	Zr
7.8KCps	4.0 KCps	263.9 KCps	3.5 KCps	20.7 KCps	131.4 KCps	4.8KCps
0.351%	0.0691%	3.10%	0.00318%	0.0378%	0.0194 %	0.0443%

Compton	Rayleigh	Norm.
0.81	1.38	100.00%