EFFECT OF SOIL TYPES ON EROSION

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ABSTRACT

Slope erosion has been a global phenomenon over the century. However, only few further researches have been discovered in this area. Soil erosion is the process involving detachment and transportation of soil from the soil origin. Soil erosion is one form of soil degradation along with soil compaction, low organic matter, and loss of soil structure, poor internal drainage, and soil acidity problems. There is some factor that might cause erosion. One of the factors is the type of soil and its particle size. A study using soil erosion modeling was conducted to determine how effective the type of soil will influenced erosion. The size of the test bed tray is 400mm in wide, 100mm of height and 800mm length. Each test will contain different percentage of soil. There are total 3 mixed of soil in this test. First sample will use 10% of silty clay and 90 % of sand from the total weight of the mixed. Then for second sample will use 70 % of silty clay and 30 % of sand. For the last sample will use 50% of silty clay and sand. Each test will run approximately 15 minutes. Generally the results showed that the erosion increased when soil particle size is increased. From the observation of each test, then the erosion index is calculated and determined.

ABSTRAK

Hakisan cerun telah menjadi satu fenomena global sejak awal dulu lagi walau bagaimana pun hanya sedikit penyelidikan lanjut dilakukan dalam a . Hakisan tanah merupakan satu bentuk degradasi tanah bersama-sama dengan pemadatan tanah, bahan organik , dan kehilangan struktur tanah, saliran dalaman yang rendah dan masalah keasidan tanah. Terdapat beberapa faktor yang mungkin menyebabkan hakisan. Salah satu faktor adalah jenis tanah dan saiz zarahnya. Satu kajian menggunakan model hakisan tanah telah dijalankan untuk menentukan keberkesan jenis tanah mempengaruhi hakisan. Saiz bekas ujian adalah 400mm lebar dengan ketinggian 100mm dan panjang 800mm. Setiap ujian akan menggunakan peratusan tanah yang berbeza. Terdapat 3 jenis campuran tanah dalam ujian ini. Sampel pertama menggunakan 10% daripada tanah liat berkelodak dan 90% daripada pasir dari jumlah berat campuran. Kemudian sampel kedua akan menggunakan 70% daripada tanah liat berkelodak dan 30% daripada pasir. Bagi sampel yang terakhir akan menggunakan 50% tanah liat berkelodak dan pasir. Setiap ujian akan berlangsung kira-kira 15 minit. Secara amnya, keputusan menunjukkan bahawa hakisan meningkat apabila saiz zarah tanah meningkat. Dari pemerhatian setiap ujian, maka indeks hakisan dikira dan ditentukan.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Landslide is always said to be the effect of continuous rainfall for a continuous days or due to the high intensity of rainfall. There were many cases reported on this landslide issue. The phenomena of landslide can be relates to the erosion of the soil at slope. Erosion is defined the process where the soil are detached, transported and deposition from one place to another by the influenced of wind, water and gravity forces (R.Suresh , 1993).

Soil erosion due to water is complementary process due to the rainfall impact that caused the detachment and transportation of sediment transport due to the overland flow. According to Eric Goh (2006) soil erosion phenomenon can be define as the process of the soil detachment and transportation from the natural environment. It is happen when the rainfall that caused the erosion is exceeded the infiltration rate of the disturbed soil at site.

Erosion can be divided into two major groups which are geologic and accelerated erosion. Geologic is natural erosion while accelerated erosion is erosion caused by the human or animal activities. Geologic erosion is the long term erosion process. It is the main factor that contributes to the earth formation. This type of erosion is influenced by wind, temperature difference, gravity and vegetation. The simplest example of the geologic erosion in Malaysia is the formation of hill and mountain. It

happened in the long term of eroding process with the same rate and important in maintaining the balance that suits the growth of the most plant. In the other hand, accelerated erosion is caused by the man's activity that has brought to the changes of the environment and the soil condition. Activity like development project, wide spread of uncontrolled deforestations is accelerating the soil erosion process from its nature. This type of erosion is widely happen in all countries especially in the tropical region (R.Suresh, 1993).

There are several types of erosion such as water erosion, raindrop erosion (Figure 2.1), sheet erosion, interill erosion, rill erosion and gully erosion. Water erosion are happened when the soil are detached from land and transported to another place by water like runoff. Runoff will transport the detached soil at the land surface thus decrease the stability of the soil and caused landslides. Runoff water also is one of the factors that can increase the erosion index

When rainfalls are in contact with the soil surface it will let the erosion process to occur. There are few elements that will effect the soil erosion but the main two components that involved in the soil erosion process are the erosivity of the rainfall and the erodibility of the soil. Rainfall erosivity is the relation of the rainfall ability to erode the soils that are in contact with the raindrops meanwhile the soil erodibility is the ability of the soil to withstand erosion. If the soil erosivity are exceeding the ability of the soil from being detached, then erosion process will start to take place (R.Suresh, 1993).

There are several factors that can affect the water erosion such as ambience of the soil, properties of the soil corresponding to the soil characteristics, vegetation of the land surface and the topographic effect. Soil texture is a sign for the simplicity of detachment of soil particles. The size of the soil particles will determine the threshold force necessary for particle detachment and how far the particles will be transported.

1.2 PROBLEM STATEMENT

When the erosion process takes place, the soil particles are detached from its bulk. Soil erosion is proportional to the soil detachability. If the chances of soil to be detached are high, it will increase the potential of the soil to be eroded. The soil erodibility is depended on the characteristics of the soil where the types of soil are the major factor in the erosion process followed by the other factor such as slopes compaction factor and etc. The erodibility of sand is higher compared to silty clay since sand has larger particle size than clay, therefore more energy is required to erode the soil compared to clay. Even though clay have smaller particle size compare to the sand, but the cohesion between the clay in the bulk will hold the clay together thus giving some resistance to the soil particles from easily being eroded.

Therefore these studies are aims to study the effect of the soil types on erosion.

1.3 OBJECTIVE OF STUDY

The objectives of the study are to:

i. Determine of soil properties and its erodibility.
ii. Determine correlation between rainfall erosivity and soil erosion.
iii. Understand principles of soil erosion and related process to soil erosion.

1.4 SCOPE OF STUDY

Scopes of the study include the following procedures:

i. Laboratory testing to determine the properties of soil used (sand and silty clay).
ii. Modelling of the soil erosion model to investigate the effect of the soil types towards erosion.
iii. Determination of the erodibility and degree of erosion using ROM Scale Index.
iv.

1.5 SIGNIFICANT OF STUDY

The investigation aimed to study the effects of the soil types to the soil erosion. By knowing the effect of the soil types to the soil erosion, the problems that encountered because of the soil erosion can be controlled. Besides that, the correlation between the rainfall and erosion can be developed and precautions can be practiced to control the soil erosion.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Soil erosion is widely happening all around the world. It is the normal natural process that sometimes is being impaired by the human activities without any consideration of their doing. Erosion of soil is the process of soil detachment by the eroding agent such as wind, water, gravity and ice. This includes the rainfall and runoff water that work as erosion agent. Basically there are two functions for the erosion process to take place. First is the erosivity of rainfall to detach the soil and erodibility of the soil from being eroded by the erosive rainfall.

2.2 TYPES OF EROSION

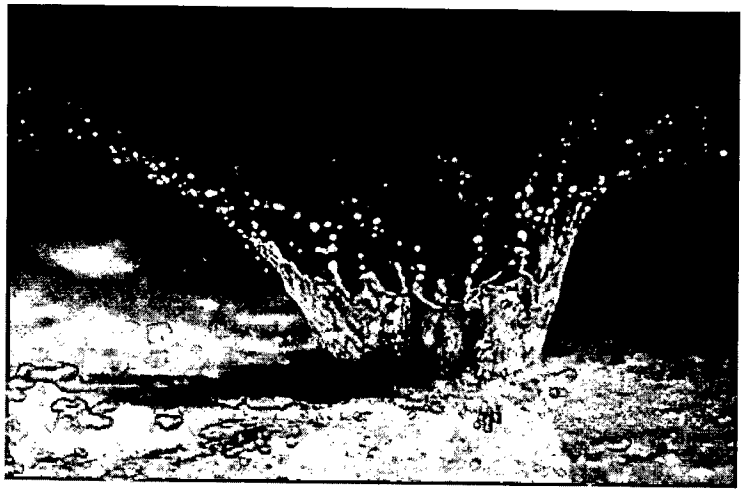
Soil erosion can be classified into two types of erosion, first is wind erosion and second is water erosion. Wind erosion is the process of detachment and transportation of the soil particles by the action of wind. It is happen in all part of the world and worst at some countries like India. Water erosion is defined as the movement or transportation of soil by the rapidly running water over the land surface.

2.2.1 Water erosion

The type of the erosion to be discussed is the erosion by water. This type of erosion is more widely happen in this region. The soil transportation process is happened when the soil are dissolved into the running water and moved from one place to another along with the water flow. There are various types of water erosion such as raindrop erosion, sheet erosion, rill erosion and gully erosion. Water erosion is accelerated by activities such as farming, deforestation and construction for development.

Raindrop erosion is the detachment of soil and runoff process from the impact of the raindrop towards the soil particles or thin soil surface. When rainfalls occur, soil is splashed to the air with the large amount more than once. The effect of a raindrop impact can be seen in the figures below (Figure 2.1 and figure 2.2).

Figure 2.1 Water splash by the raindrop.



Source: Schwab et al (2002)

Direction and distance of the soil splash are depends on the slopes, wind, soil surface condition.

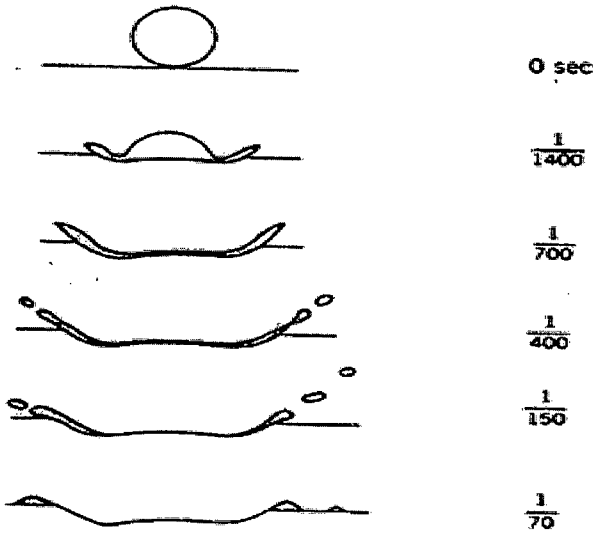


Figure 2.2 Raindrop impacts to the soil surface

Source : Schwab G.O et al (2002)

Sheet erosion was the uniform removal of soil surface in the thin layer of sheet instead of rill, from the sloping land (See figure 2.3 and 2.4). This type of erosion can be caused by the sheet and overland flow.

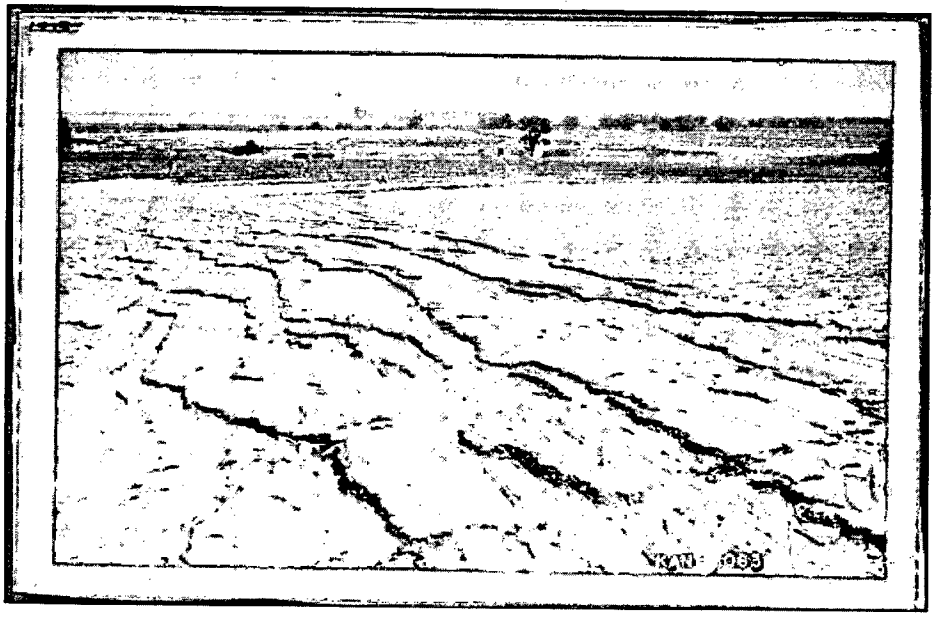


Figure 2.3 : Sheet erosion

Instead of rill erosion this rill erosion also known as a micro channels erosion. This type of erosion occurs when the soil is detached and removes by a concentrated flow of water then rills are formed (Delmar D. Fangmeier et al) . Figure 2.5 are showing the condition of rill erosion. Rill is a structure that can be removed by the normal tillage activities. In most of the erosion types these types of erosion is a predominant form of erosion that can be found. This erosion can be more serious if the topsoil is having a high erodibility characteristic especially when a highly intense storm occurs and higher runoff water flowing.

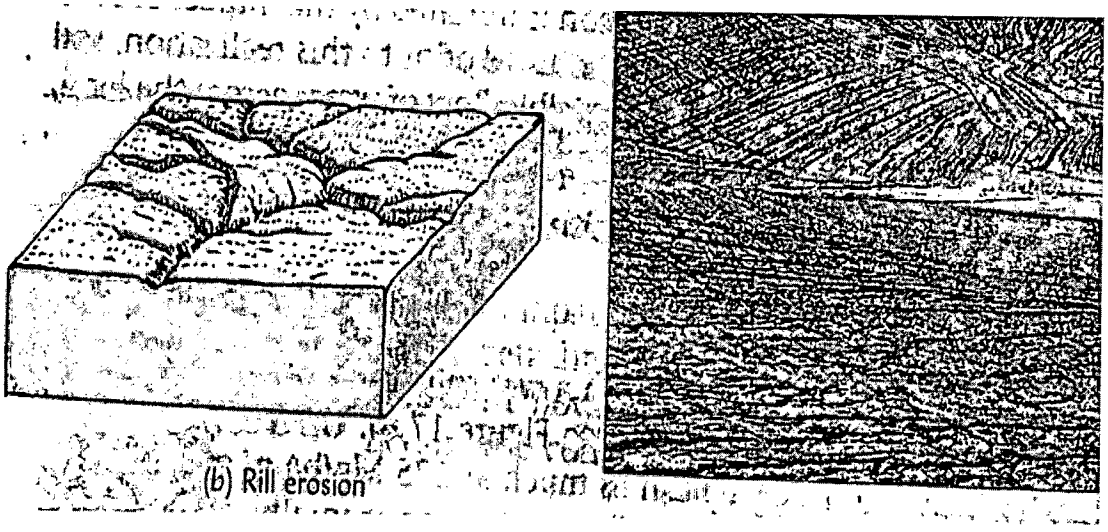


Figure 2.5 Example of rill erosion

Gully erosion produces channel larger than rills. These channel carry water during and immediately after rains and as distinguished from rills, gullies cannot be obliterated by tillage (Glenn O,2002). Erosion of the gully erosion is depended with the soil types and the runoff and slope of the catchment area.

2.3 FACTORS AFFECTING EROSION

Soil erosion is affected by many kind of factor includes the rainfall, soil type, landscape, crops, and farm management. There were many studies that have conducted in order to studies how far the above mention factors have gives impact towards soil

erosion. It is vital to study the factor that may lead to the soil erosion in order to finding step and method to decrease the effect soil surface erosion.

In order to find the effect of soil types, peat, slope and compaction effort towards soil erodibility, a study was conduct to study the above mention factor to the soil erodibility and how they react with the wash erosion such rainfall runoff and infiltration that pass through the soils. E.I Kwue (2010) in his journal said that the increasing of peat content inside the soil will increase it toughness of soil towards erosion. In the other hand the peat works as fibre toward the soil. In his study, the test used three different types of soil: Piarco sandy loam, Maracas clay loam and Talparo Clay and slopes varied from 9%,15%, 21% , 25% and 30%. Figure 2.7 shows the result of the test conducted by E.I Kwue (2010).

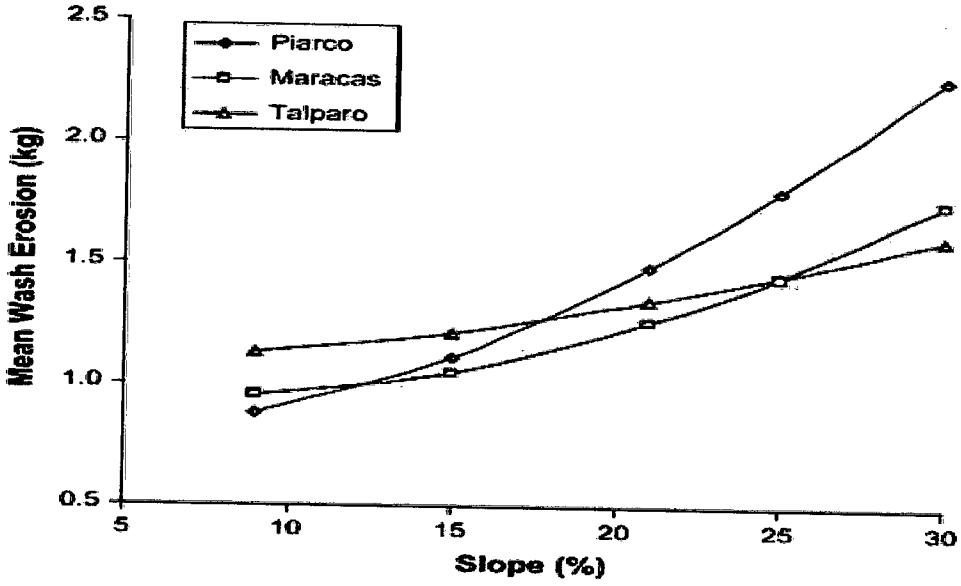


Figure 2.7 : Result of wash erosion to the varied slopes and soils.
Source: Bharat, C etal, (2010)

From the result shown, sandy loam makes greater soil erosion compare to the clay. The erosion is getting higher as the slopes are increased.

Soil is an essential input to agricultural production and in Nigeria where agricultural production is crucial to development the livelihoods of the majority of the

population depend on this naturally abundant resource (Idah P.A etal. ,2008). The research was conducted by Determination of Erodibility Indices of Soils in Owerri West Local Government Area of Imo State, Nigeria. Test on different kind of soil is conducted thus the erodibility of the soil at that area was determined. The test of the study conducted by him is shown in the Table 2.1.

Table 2.1 Average erodibility index (*K*) of project locations and predicted soil losses for the various communities using Hudson (1995) equation.

Location	Average *K*-index	Soil loss (tons/ha/yr)
Ndegwu	0.035	7.526
Orogwe	0.040	8.602
Amakohia Ubi	0.40	8.602
Obinze	0.029	6.236
Oforola	0.032	6.881
Avu	0.03	6.451
Umuguma	0.036	7.741
Okolochi	0.036	7.741
Emeabia	0.033	7.096
Eziobodo	0.032	6.881
Ihiagwa	0.029	6.236
Nekede	0.034	7.311
Irete	0.036	7.741
Ohi	0.044	9.462
Okuku	0.037	7.95

Source : Idah, P.A etal (2008)

From the particle size analysis sandy soils were found to be the most common. Erodibility factors of Ohi, Orogwe and Amakohia-Ubi communities were found to be high which is due to the presence of high quantity of sandy soils in these areas. Sandy soils are known to have low cohesive force and therefore it more prone to detachment and transportation by water and wind. Furthermore, high sandy soil content encourages high rate of permeability of water into the soil, which induces landslide and erosion.

Table 1. Average laboratory analyses of soil samples.

Land use	% OM	% Clay	% Silt	% sand	VFS	structure code	Permability code
Pasture 3-8%	1.76	44.44	24.96	30.60	28.52	3	1
Pasture 8-18%	1.69	38.49	50.88	10.63	1.12	3	2
Pasture 18-40%	1.72	14.68	54.71	30.61	22.99	3	3
Forest 3-8%	6.26	22.09	52.51	25.41	15.77	4	4
Forest 8-18%	6.55	20.21	55.21	24.58	20.56	4	4
Forest 18-40%	6.09	19.89	10.87	69.25	59.58	4	4
Irrigated farming 3-8%	2.21	20.88	52.62	26.50	18.68	4	3
Irrigated farming 8-18%	2.64	14.60	52.43	32.97	31.94	4	5
Irrigated farming 18-40%	0.80	3.60	30.76	65.63	17.97	4	4
Dry farming 3-8%	2.87	21.53	52.47	25.99	16.70	3	1
Dry farming 8-18%	1.84	17.42	48.86	33.72	21.55	4	2

Figure 2.8 : Laboratory test result by the study conducted

Source: Shabani F et al (2010)

From the study conducted the K factor of the test is using Eq 2.2

$$K = A/R \qquad \text{Equation 2.2}$$

From the study reviewed it is proposed that the relationship of the clay content and the K factor obtained using data from the station if there is no significance difference in percent of organic matter is shown in Figure 2.9. From the review of Figure 2.9, the erodibility is increased with the decreasing of the clay content.

Apart from that the erosion index of soil can be determined by using ROM Scale Index. The index is used to determine the landslide level of the soil. A study was conducted by Jaafar,M et al (2011) to determine the landslide index of 12 problematic slope location around Universiti Kebangsaan Malaysia (UKM), Bangi. Review of the study conducted the soil texture was dominated by sand and clay for each of the testing station. ROM Scale Index was use to determine the erosion index of the slope.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will describe the method and test used in collecting the data. In this chapter, the detail of the methodology used to conduct this study will be discussed. Figure 3.1 shows flow of activities of this study. The appropriate method should be carefully selected in order to obtain the accurate expected result. The test can be classified into two types which are soil properties and erosion modelling. The entire laboratory testing conducted is referring British Standard Code 1377:1990 and ASTM.

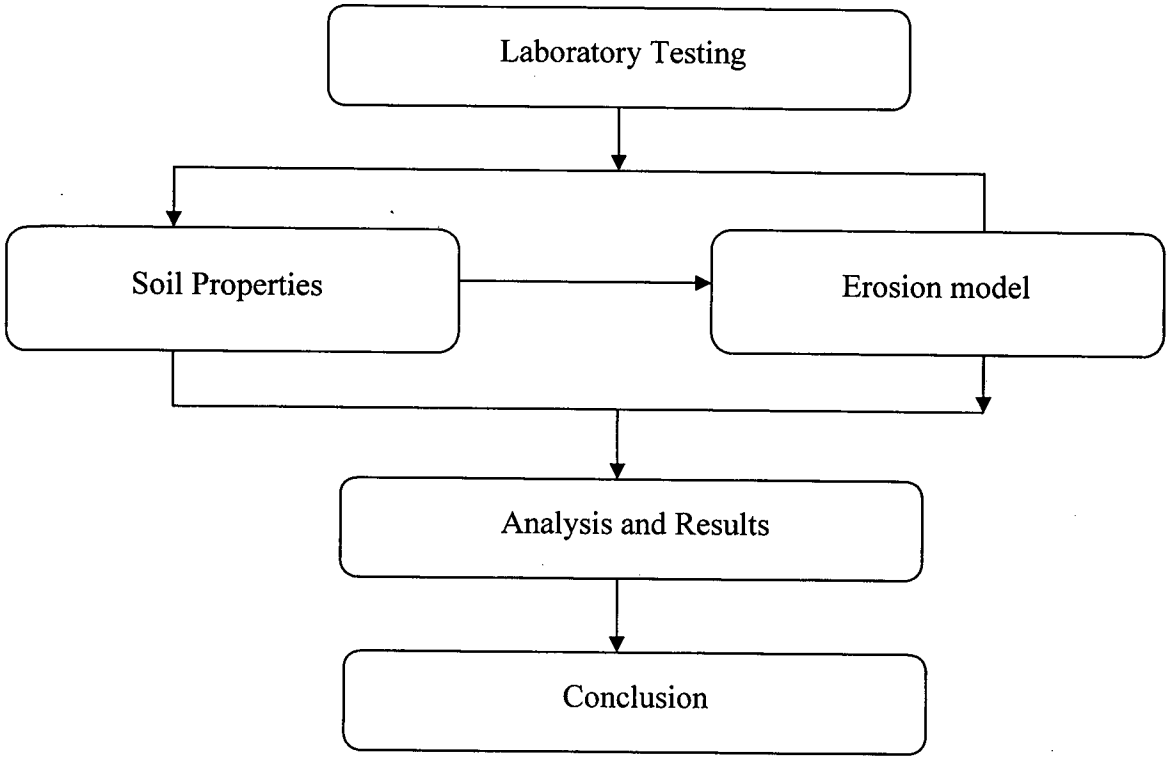


Figure 3.1: Methodology flow chart

3.2 PREPARATION OF SAMPLE

3.2.1 Type of soil samples

They are 2 types of soil used in this study which are silty clay and sand. But the soils then are mixed to a few percentages of sand and clay to form three soil samples. Table 3.1 shows the percentage of sand and silty clay in each of soil samples proposed.

Table 3.1 : Percentage of clay and sand in the soil sample.

Soil Sample	Soil type	
	Sand (%)	Clay (%)
A	80	20
B	30	70
C	50	50

The testing for the determination of the soil erodibilty is conducted using soil samples shown in Table 3.1.

3.2.2 Origin of soil sample

The soil sample was taken from 2 sites representing 2 types of soil proposed to use in the study. For the silty clay, soil is obtained from a land behind the Kolej Kediaman 2, Gambang Campus, Universiti Malaysia Pahang. The soil were dug by using an ordinary hoe and shovel about depth of 0.5 metre below the ground level while the river sand proposed is taken from the FKASA concrete laboratory.

3.3 SAMPLE TESTING

There were a few test conducted in order to obtain all the data to be discussed in the next chapter. From Figure 3.1 it shown that, there were two types of testing conducted to be analysed in Chapter 4.The test conducted , is to determined the basic

properties of the soil used and testing of the soil sample using the erosion model to determine the soil loss from the erosion model. The soil loss obtained from the test is then compared to the ROM Scale Index to determine its degree of erosion.

3.3.1 Basic soil properties test.

In order to determine the basic properties of the soil used, there are a few test conducted such as specific gravity test, Atterberg limit test and particle size distribution.

3.3.1.1 Specific gravity

This test is performed to determine the specific gravity of the silty clay and sand used in preparing the soil samples by using the density bottle. The capacity of the density bottle used is 50 mL (Figure 3.2). The test is using the standard method and procedure of BS1377: Part 2: 1990:8:3, a standard test of specific gravity for fine grained soil using density bottle. The result obtained from this test to be discussed in the chapter 4. The apparatus used for this test is shown in the Figure 3.3.

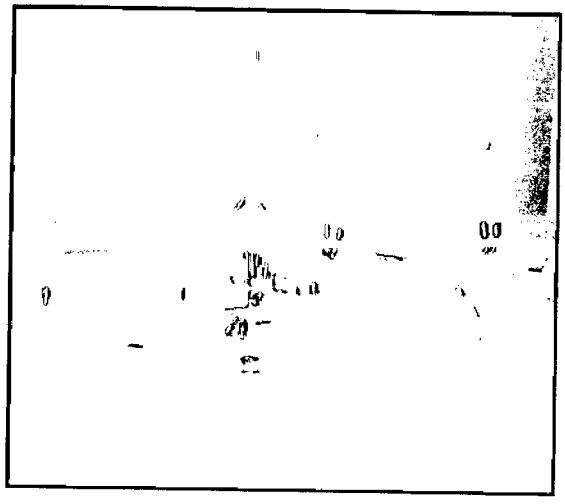


Figure 3.2 : Density bottle.

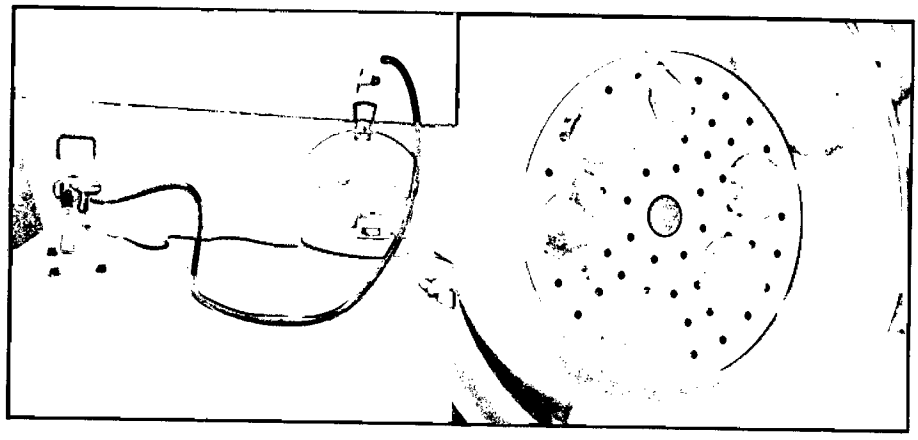


Figure 3.3 : Specific gravity apparatus.

3.3.1.2 Atterberg limit test.

Atterberg limit test is conducted to determine the plastic limit, liquid limit and plasticity index of the silty clay used .The test is conducted by using the method and procedure according to BS1377: Part 2:1990. The result obtained from this test is to be discussed in chapter 4. The apparatus used for this test is shown in the Figure 3.4 and 3.5.