# Modified soil erodibility factor, K for Peninsular Malaysia soil series

MOHD FAZLY YUSOF, *Research Officer, River Engineering and Urban Drainage Research Centre (REDAC), Universiti Sains Malaysia, Engineering Campus, Seri Ampangan, 14300 Nibong Tebal, Penang, Malaysia. Email: redac07@eng.usm.my*

ROZI ABDULLAH, *Associate Professor, School of Civil Engineering, Universiti Sains Malaysia, Engineering Campus, Seri Ampangan, 14300 Nibong Tebal, Penang, Malaysia. Email: cerozi@eng.usm.my*

HAZI MOHAMMAD AZAMATHULLA, *Senior Lecturer, REDAC, Universiti Sains Malaysia, Engineering Campus, Seri Ampangan, 14300 Nibong Tebal, Penang, Malaysia. Email: redacazamath@eng.usm.my*

NOR AZAZI ZAKARIA, *Professor & Director, REDAC, Universiti Sains Malaysia, Engineering Campus, Seri Ampangan, 14300 Nibong Tebal, Penang, Malaysia. Email: redac01@eng.usm.my*

AMINUDDIN AB. GHANI, Professor & *Deputy Director, REDAC, Universiti Sains Malaysia, Engineering Campus, Seri Ampangan, 14300 Nibong Tebal, Penang, Malaysia. Email: redac02@eng.usm.my*

**ABSTRACT**
Soil erodibility factor (susceptibility of soil to be lost to erosion) is one of the components of the Universal Soil Loss Equation (USLE). The usage of soil erodibility equation or nomograph by Wischmeier (1971) is the most widely used in determined soil erodibility factor, K in the world. The estimated of *K* value may be made if the grain-size distribution, organic content, structure and permeability of the soil are known. Many attempts have been made to devise a simple index of erodibility based either on the properties of the soil as determined in the laboratory or the field, or on the response of the soil to rainfall. In Malaysia, a study carried by Tew (1999) using 26 soil series of highland area has lead to the establishment of soil erodibility equation for Peninsular Malaysia soil series which are more reliable to compare with K value of Wischmeier equation. An extensive study using 74 soil series of Peninsular Malaysia of Department of Agriculture (DOA) Malaysia soil survey data has been carried out in 2010 in determining soil erodibility factor, K using Tew (1999) equation with some modification on method of determined soil structure and soil permeability code. The result from the assessment shows that the K value for 74 soil series of Peninsular Malaysia gives better information to engineers in determining the soil loss and sediment yield for a given development area. Further study need to be carried out for soil series with high sand and silt content if Tew equation to be use in determining K values.

*Keywords*: Soil erodibility, Wischmeier erodibility equation, Tew erodibility equation, Peninsular Malaysia soil series.

## 1 Introduction

Soil can be eroded from its present state by the action of water, and wind. Soil erosion by water, is the process of soil particles detachment by the impact of rainfall and runoff, and its transport down the slope. Erosion from mountainous areas and agricultural lands are the major source of sediment transported by streams and deposited in reservoirs, flood plains, and deltas. Sediment load is also generated by erosion of the beds and banks of streams, by the mass movements of sediment such as landslides, rockslides and mud flows, and by construction activity of roads, buildings and dams. Malaysia cannot avoid from having erosion and sedimentation problems as many parts of the country are experiencing rapid development, e.g. land clearing for housing, logging, and agriculture. While these activities are necessary for the development of the country, regulatory efforts to minimize erosion and sedimentation problems should not stifle economic development planned for attaining a developed country status by year 2020.

Soil erodibility the K factor in the Universal Soil Loss Equation, USLE (Wischmeier and smith, 1978) is defined as the rate of soil loss per erosivity index unit as measured on a standard plot 22.1m long, has a 9% slope and continuously in a clean-tilled fallow condition, with tillage performed up and downslope. Soil erodibility or *K* factor is one of the most important factors necessary for the determination of soil loss or sediment yields for interrill and rill erosion. Soil erodibility is a complex property and is thought of as the ease with which soil is detached by splash during rainfall or by surface flow, or both. The soil-erodibilty factor (*K*) in the RUSLE accounts for the influence of soil properties on soil loss during storm events on upland areas (Hashim and Wan Abdullah, 2005). The estimated of *K* value may be made if the grain-size distribution, organic content, structure and permeability of the soil are known (Wischmeier, Johnson and Cross, 1971).

## 2 Soil Erodibility Factor, K for Peninsular Malaysia

Many attempts have been made to devise a simple index of erodibility based either on the properties of the soil as determined in the laboratory or the field, or on the response of the soil to rainfall (Table 1). The most widely used and frequently cited relationship is the soil-erodibility nomograph (Weischmeier et al. 1971). The nomograph, shown in Figure 1 comprises 5 soil and soil-profile parameters: percent of modified silt (0.002-0.1 mm), percent of modified sand (0.1-2 mm), percent of organic matter (OM), class for soil structure (s) and soil permeability (p).

A useful algebraic approximation (Weischmeier and Smith, 1978) as in Eq. 1 of the nomograph for those cases where the silt fraction does not exceed 70% is

$$K = \left[2.1x10^{4}(12-OM)M^{1.14} + 3.25(s-2) + 2.5(p-3)\right]/100 \quad (1)$$

Where $M$ - the product of the primary particle size fraction (% modified silt or the 0.002-0.1 mm size fraction) x (% silt + % sand).

$K$ - Soil erodibility index in ton/ac (100 ft-tons in/ac.h). Division of the right side of this equation with 7.59 will yield K values expressed in SI units.

Table 1 Indices of soil erodibility for water erosion (Morgan, 1996)

| | | |
|---|---|---|
| **Static Laboratory Tests** | | |
| Dispersion ratio | $\frac{\%\ silt + \%\ clay\ in\ undispersed\ soil}{\%\ silt + \%\ clay\ after\ dispersal\ of\ the\ soil\ in\ water}$ | Middleton (1930) |
| Clay ratio | $\frac{\%\ sand + \%\ silt}{\%\ clay}$ | Bouyoucos (1935) |
| Surface aggregation ratio | $\frac{surface\ area\ of\ particles > 0.05\ mm}{(\%\ silt + \%\ clay\ in\ dispersed\ soil) - (\%\ silt + \%\ clay\ in\ undispersed\ soil)}$ | André and Anderson (1961) |
| Erosion ratio | $\frac{dispersion\ ratio}{colloid\ content{:}moisture\ equivalent\ ratio}$ | Lugo-Lopez (1969) |
| Instability index (Is) | $\frac{\%\ silt + \%\ clay}{Ag_{air} + Ag_{alc} + Ag_{benz}}$ where $Ag$ is the % aggregates >0.2 mm after wet sieving for no pretreatment and pretreatment of the soil by alcohol and benzene respectively | Hénin, Monnier and Combeau (1958) |
| Instability index (Is) | $\frac{\%\ silt + \%\ clay}{(\%\ aggregates > 0.2\ mm\ after\ wet\ sieving) - 0.9\ (\%\ coarse\ sand)}$ | Combeau and Monnier (1961) |
| Pseudo-textural aggregation index (Ipta) | $\frac{MWDw - MWDt}{X - MWDt} \cdot 100$ where $MWDw$ is the mean weight diameter of the wet-sieving grain size distribution (mm), $MWDt$ is the mean weight diameter of the primary particle grain-size distribution (mm) and $X$ is the maximum average grain-size diameter of the particles in the given grain-size distribution | Chisci, Bazzoffi and Mbagwu (1989) |
| **Static Field Tests** | | |
| Erodibility index | $\frac{1}{mean\ shearing\ resistance \times permeability}$ | Chorley (1959) |
| Soil cohesion | direct measure of soil cohesion at saturation using a torvane | Rauws and Govers (1988) |
| **Dynamic laboratory tests** | | |
| Simulated rainfall test | comparison of erosion of different soils subject to a standard storm | Woodburn and Kozachyn (1956) |
| Water-stable aggregate (*WSA*) content | % *WSA* >0.5 mm after subjecting the soil to rainfall simulation | Bryan (1968) |
| Water drop test | % aggregates destroyed by a pre-selected number of impacts by a standard raindrop (e.g. 5.5 mm diameter, 0.1 g from a height of 1 m) | Bruce-Okine and Lal (1975) |
| Erosion index | $\frac{dh}{a}$ where $d$ is an index of dispersion (ratio of % particles >0.05 mm without dispersion to % particles >0.05 mm after dispersion of the soil by sodium chloride); $h$ is an index of water-retaining capacity (water retention of soil relative to that of 1 g of colloids); and $a$ is an index of aggregation (% aggregates >0.25 mm after subjecting the soil to a water flow of 100 cm/min for 1 h) | Voznesensky and Artsruui (1940) |
| **Dynamic Field Tests** | | |
| Erodibility index ($K$) | mean annual soil loss per unit of $EI_{30}$ | Wischmeier and Mannering (1969) |

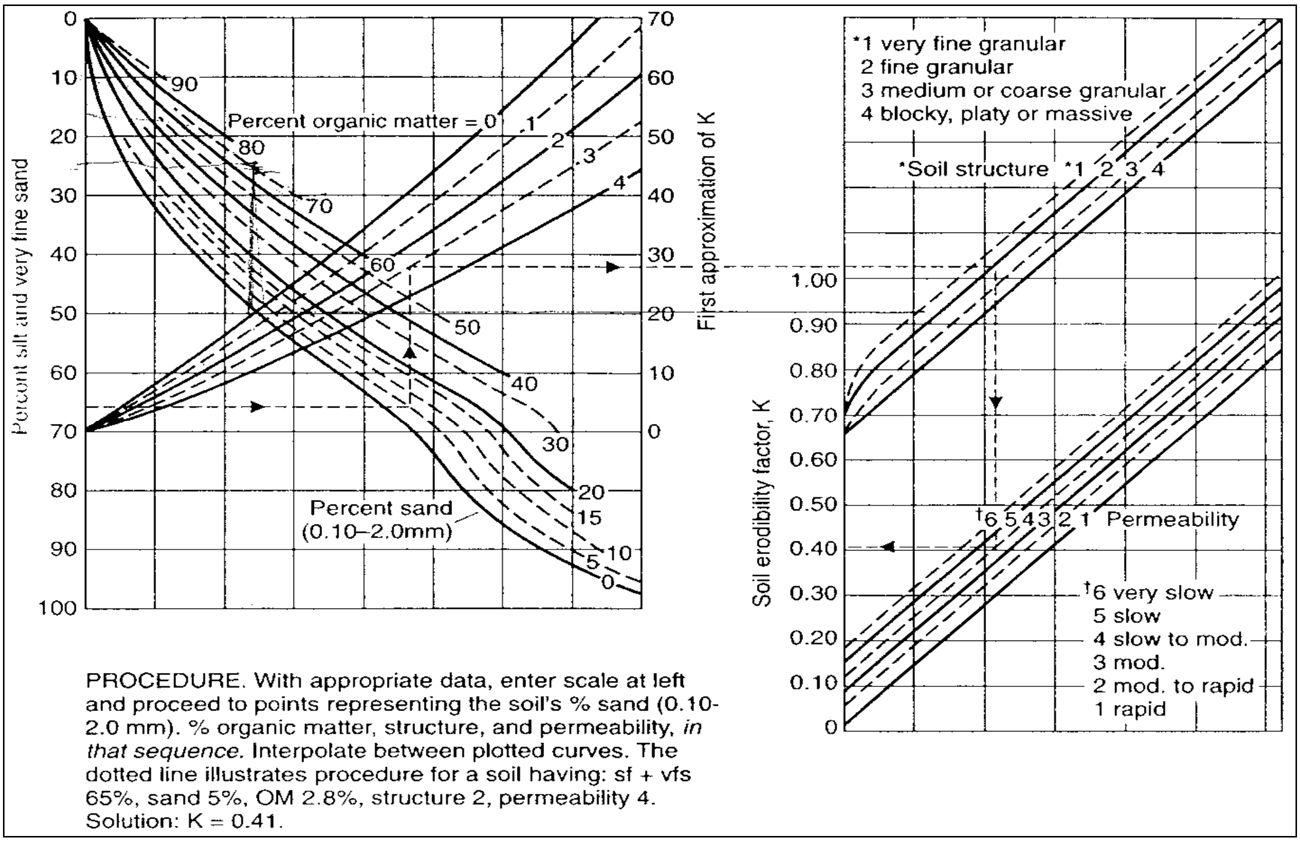


Figure 1 Nomograph for computing the K value of soil erodibility in imperial unit (Wischmeier et al., 1971)

## 3 Tew Equation for Soil Erodibility Factor of Peninsular Malaysia Soil Series

Extensive work has also been carried by Tew (1999) to produce a Malaysian condition soil erodibility nomograph, based on unmodified nomograph (Wischmeier et al., 1971) and relative K values obtained from experimental work using a portable rainfall simulator. In the study, the 26 soil series in Peninsular Malaysia are obtained from the Department of Agriculture (DOA, 1995) and was divided into seven (7) main groups as shown in Table 2 below. From the data obtained, the percentages of clay, silt, very find sand and sand passing 0.06 – 2 mm sieve were extracted and the values of organic matter content, soil structure and permeability of these soil series are obtained through experimental studies and observation. For the value of K was obtained from the unmodified nomograph and relative K obtained from experimental study is shown in Table 3.

Table 2 Soil Group for 26 Malaysian Soil Series (DOA, 1995)

| *Soil Group* | *Soil Series* |
|---|---|
| 1 | Batu Lapan,Marang, Mat Daling,Serdang |
| 2 | Muchong,Kuah,Mat Jempul Durian |
| 3 | Tangga, Terap |
| 4 | Kemahang, Merapoh, Baling, Kuala Nerang |
| 5 | Laka, Nami, Jitra |
| 6 | Bongor, Jeragau, Beserah, Renggam, Lanchang, Ketak, Pulau Besar |
| 7 | Holyrood, Batang Merbau |

Table 3 K nomograph and Relative K value for Malaysian soil series (Tew, 1999)

| *Soil Series* | *Soil Group* | *K Nomograph* | *K Relative* |
|---|---|---|---|
| B. Lapan | 1 | 0.379 | 0.03542 |
| Marang | 1 | 0.409 | 0.19375 |
| Mat Daling | 1 | 0.320 | 0.12569 |
| Serdang | 1 | 0.310 | 0.12082 |
| Munchong | 2 | 0.347 | 0.01750 |
| Kuah | 2 | 0.395 | 0.08750 |
| Mat Jempul | 2 | 0.230 | 0.17910 |
| Durian | 2 | 0.279 | 0.02528 |
| Tangga | 3 | 0.055 | 0.03308 |
| Terap | 3 | 0.075 | 0.19014 |
| Kemahang | 4 | 0.252 | 0.24485 |
| Merapoh | 4 | 0.280 | 0.02522 |
| Baling | 4 | 0.288 | 0.18555 |
| K. Berang | 4 | 0.199 | 0.04167 |
| Laka | 5 | 0.440 | 0.00000 |
| Nami | 5 | 0.444 | 0.34826 |
| Jitra | 5 | 0.545 | 0.05799 |
| Bongor | 6 | 0.374 | 0.43819 |
| Jerangau | 6 | 0.040 | 0.02896 |
| Beserah | 6 | 0.080 | 0.02828 |
| Renggam | 6 | 0.103 | 0.13149 |
| Lanchang | 6 | 0.160 | 0.02799 |
| Ketak | 6 | 0.220 | 0.59056 |
| P. Besar | 6 | 0.240 | 0.12222 |
| Holyrood | 7 | 0.115 | 0.10861 |
| B. Merbau | 7 | 0.110 | 0.04297 |

Modifications are then carried out stage by stage to get the best correlation between the relative K value and the predicted K value from the existing nomograph to produce a nomograph for Malaysian soil series. This procedure is carried out by modifying the 4 parameters in the nomograph, namely:

a. Percentage of sand passing 0.06 – 2.0 mm
b. Percentage of organic matter content
c. Soil structure
d. Permeability

The resulted nomograph is shown in Figure 2. From the stage by stage modification, a similar equation (Eq. 2) with an error of $\pm$ 0.05 is derived (Tew, 1999) for the calculation of Soil Erodibility for Malaysia Soil Series.

$$K = \left[1.0x10^{-4}(12 - OM)M^{1.14} + 4.5(s-3) + 8.0(p-2)\right]/100 \qquad \text{(Eq. 2)}$$

Where

| | | |
|---|---|---|
| K | – | Soil Erodability Factor, (ton/ac.)*(100ft.ton.in/ac.hr) For SI unit (ton/ha)(ha.hr/MJ.mm), the conversion factor is 0.13175 or 1/7.59 |
| *M* | - | (% silt + % very fine sand) x (100 - % clay) |
| *OM* | - | % of organic matter |
| *S* | - | Soil structure code |
| *P* | - | Permeability class |

## 4 Method

An extension of data for 76 soil series for Peninsular Malaysia from soil survey data (DOA, 2010) as shown in Figure 3 was obtained and determined for the soil erodibility factor, K using Equation 2 (Tew, 1999). The Weischmeier method has been found significantly over-estimated the K factor by Tew (DID, 2010) for Malaysia soil series. The data will be extracted for the parameters that required in Tew equation and tabulated as in Table 4.

The soil-erodibility, *K* factors for layer A, B and C as in Table 5 below for each soil type are also calculated and determined.

Generally, the values of *K* for layer A are used when the soil is in natural state and not being disturbed, whereas, the respective values for B and C soil layers are used in determining soil loss at construction sites because these layers are normally left exposed after mechanical action.

Table 5 Soil Layer for Soil Series in Malaysia

| **Soil Layer** | **Soil Layer Texture** | **Soil Layer Depth (m)** |
|---|---|---|
| A | Surface soil | 0.00 – 0.50 |
| B | Subsoil | 0.51 – 1.00 |
| C | Substratum | 1.01 – 1.50 |

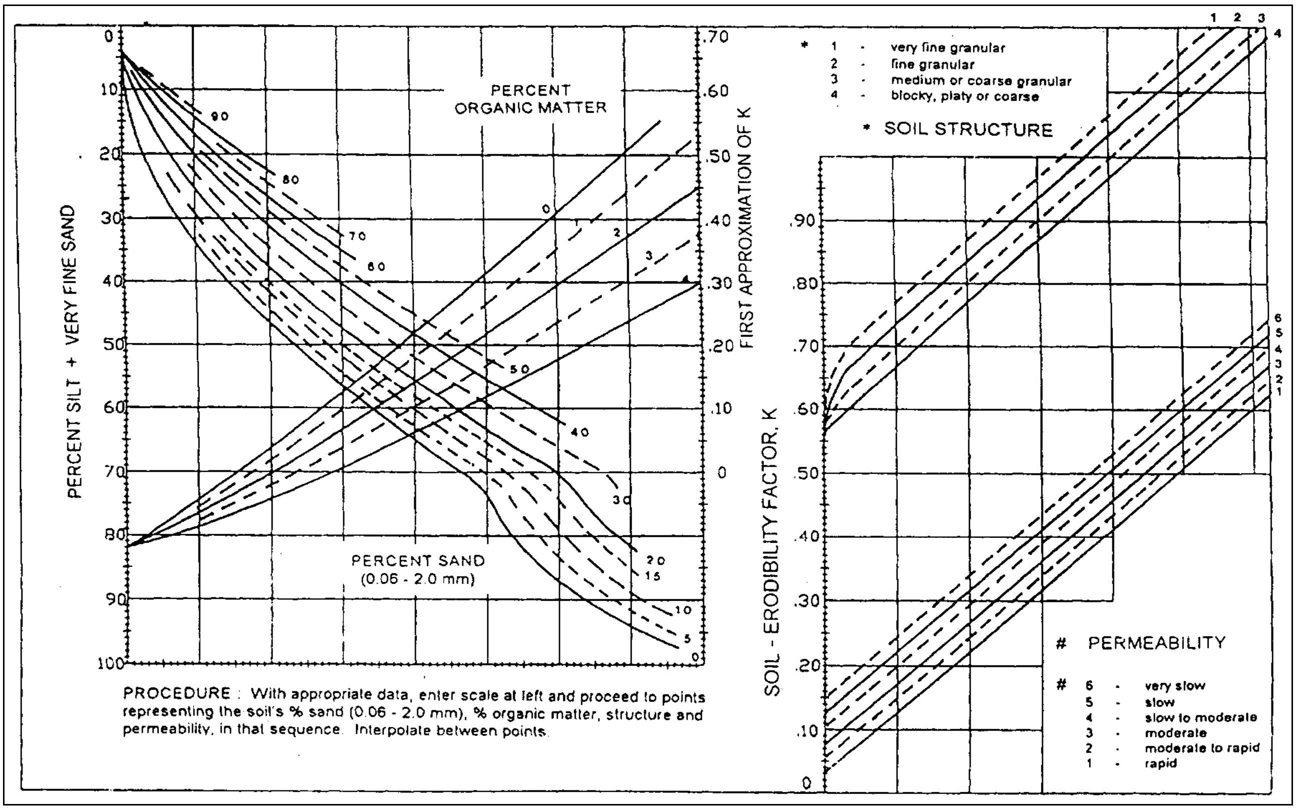


Figure 2 Malaysian soil erodibility nomograph for calculation of Soil erodibility factor, K (Tew, 1999)

Table 4 Sample of soil data extracted from soil survey report (Source: Department of Agriculture, DOA)

| No | Soil Series | Symbol | Depth (cm) | Clay % | Fine Silt % | Coarse Silt % | Very Fine Sand % | Find Sand % | Medium Sand % | Coarse Sand % | Organic Matter % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Bungor | Ap | 0-20 | 32.60 | 2.90 | 3.40 | 4.90 | 10.90 | 15.30 | 30.00 | 3.38 |
| | | $Bt_1$ | 20-42 | 42.50 | 4.90 | 3.10 | 4.50 | 10.00 | 13.10 | 21.90 | 1.63 |
| | | $Bt_2$ | 42-70 | 49.10 | 8.70 | 3.00 | 4.20 | 8.90 | 10.80 | 15.30 | 1.43 |
| | | $BC_1$ | 70-100 | 45.80 | 12.00 | 3.20 | 3.90 | 7.70 | 9.60 | 17.90 | 1.13 |
| | | $BC_2$ | 100-150 | 45.00 | 17.00 | 3.60 | 3.60 | 6.50 | 8.10 | 16.30 | 0.63 |
| 3 | Rudua | $A_1$ | 0-10 | | 33.90 | 0.91 | 1.31 | 1.91 | 12.89 | 81.47 | 8.76 |
| | | $E_1$ | 10-30 | | 30.20 | 0.69 | 0.69 | 1.98 | 39.76 | 55.39 | 0.85 |
| | | $E_2$ | 30-60/70 | 3.76 | 27.90 | 0.56 | 0.56 | 1.80 | 27.79 | 64.13 | 0.37 |
| | | $Bhs_1$ | 60/70-80 | 3.96 | 29.00 | 2.18 | 2.97 | 4.46 | 38.81 | 46.14 | 7.76 |
| | | $Bhs_2$ | 80-100 | 3.88 | 34.00 | 1.84 | 2.23 | 5.63 | 43.50 | 41.46 | 2.51 |
| | | $Bhs_3$ | 100-150 | 3.89 | 29.20 | 1.55 | 1.85 | 1.95 | 27.07 | 62.24 | 6.72 |
| 4 | Rusila 1 | Ah | 0-10 | 5.74 | | 1.36 | 4.07 | 21.48 | 44.42 | 22.94 | 10.33 |
| | | $B_1$ | 10-60 | 9.55 | | 2.31 | 4.82 | 19.70 | 44.92 | 18.69 | 9.00 |
| | | $2B_2$ | 60-95 | 1.49 | | 0.80 | 1.19 | 20.08 | 53.88 | 22.56 | 0.45 |
| | | $2B_3$ | 95-140 | 1.52 | | 1.21 | 3.14 | 20.55 | 54.66 | 18.93 | 8.19 |
| | | $2B_4$ | 140-150 | 5.36 | | 0.78 | 2.05 | 18.23 | 48.54 | 25.05 | 7.30 |

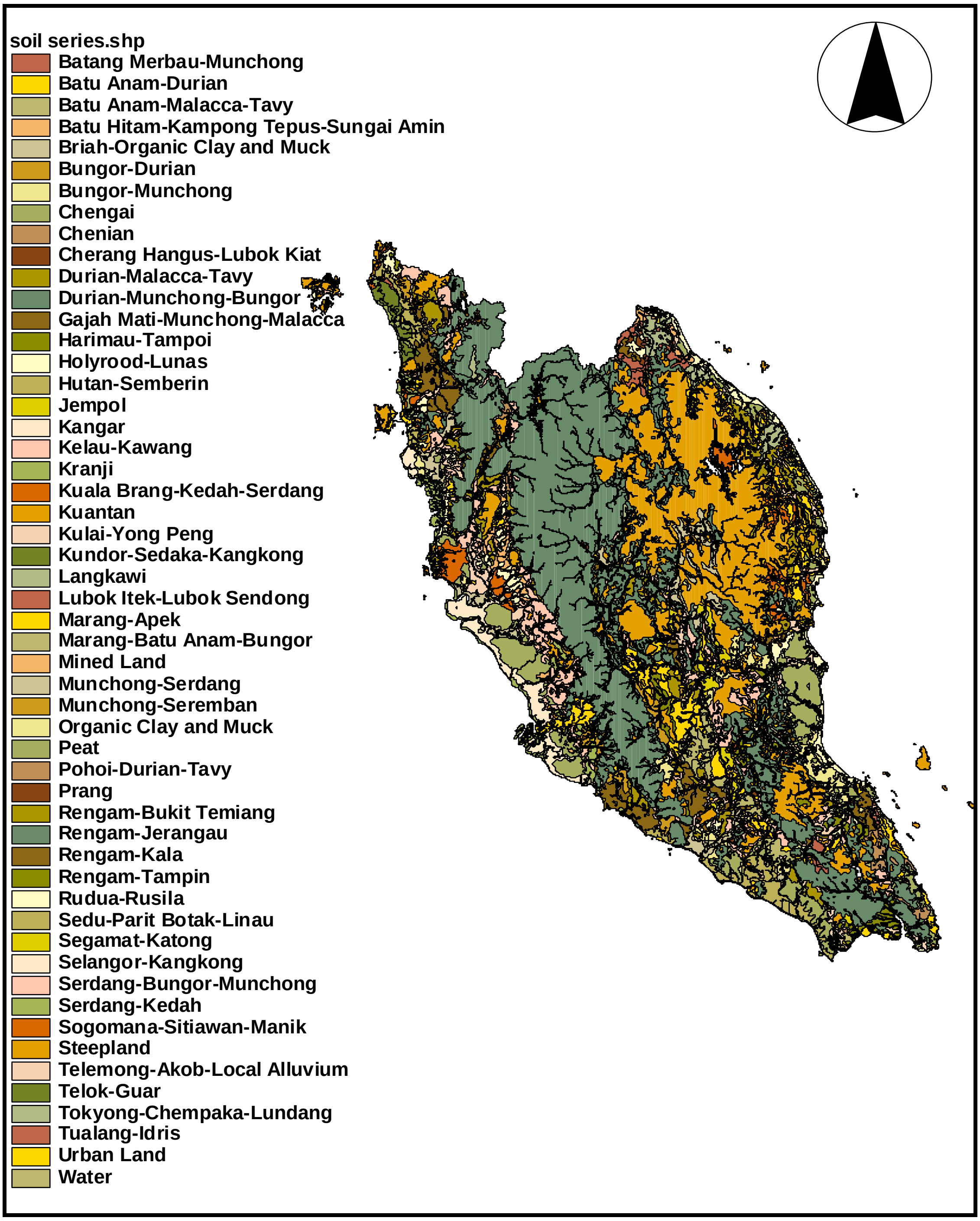


Figure 3 Soil Map for Peninsular Malaysia Soil Series (DOA, 2010)

## 5 Determination of *M* Value

The *M* value, which represents for silt, very fine sand and clay content, in Tew Equation can be obtained from particle size distribution of the soil from test of wet or dry sieving analysis in according to BS 1377: Part 2, 1990. The classification standard normally used for Malaysia soil series is based on the British Standards Institution or International Society of Soil Science. Figure 4 shows the range of particle size for both of the classification standards, and that suggested by United State Department of Agriculture (USDA).

In determining of the *M* value, the percentage of silt, very fine sand and clay for each layer of all the soil series have been extracted from soil survey report. The values of *M* are then calculated using spreadsheet software, e.g. Microsoft Office Excel.

| 0.002 | 0.006 | 0.02 | 0.06 | 0.2 | 0.6 | 2.0 mm | |
|---|---|---|---|---|---|---|---|
| CLAY | Fine | Medium | Coarse | Fine | Medium | Coarse | GRAVEL |
| | SILT | | | SAND | | | |

(i) British Standard Institution

| 0.002 | 0.02 | 0.2 | 2.0 mm | |
|---|---|---|---|---|
| CLAY | SILT | SAND | | GRAVEL |
| | | Find | Coarse | |

(ii) International Society of Soil Sciences

| 0.002 | | 0.05 | 0.10 | 0.25 | 0.5 | 1.0 | 2.0 mm |
|---|---|---|---|---|---|---|---|
| CLAY | SILT | Very Fine | Fine | Med. | Coarse | Very Coarse | GRAVEL |
| | | SAND | | | | | |

(iii) United States Department of Agriculture

Figure 4 Soil Classification Standards

## 6 Determination of *OM* Value – Organic Content

The percentage of organic content in the soil can be determined by pre-treatment with hydrogen peroxide by taking the different of weight before and after the pre-treatment. The organic content is comparatively small in quantity of the soil and it is normally removed by the pre-treatment process before mechanical separation. The percentage of these values can also be obtained from the soil survey data sheet as shown in Figures 5(a) and 5(b). From the data obtained from DOA for soil series in Malaysia, most of the soil contained less than 15 percent of organic content.

## 7 Determination of *s* Value – Soil Structure Code

Most of the soils are composed of particles varying in size and shape; specific terms are needed to indicate their textural makeup and also physical properties. Three broad and fundamental s groups of soil structure are recognized as sands, loams and clays. The Soil Textural Pyramid produce by United State Geology and Soils (USGS) (Figure 6) was used in determination of the soil structure code*s* for soil series in Peninsular Malaysia.

## 8 Determination of *p* Value – Permeability Code

Permeability of a soil is a measure of the properties in which a particular fluid flows through its voids. Soils permeability is differ from each type and roughly correlated with its grain size distribution or soil texture. In determining the permeability code of the soils, the soil texture must be first determined from the soil texture pyramid as in Figure 6 as described. The soil texture class will then be used in Table 6 to determine the permeability code of the soil.

## 9 Results and Discussion

Based on the data available, the soil erodibility factor for 74 soil series in Peninsular Malaysia has been calculated using Tew equation which is more suitable for Malaysia soil series to compare with Weischmeier equation. These values of soil erodibility factor, K for each soil series together with their Soil Texture and Hydrological Soil Group are simplified as shown in Table 7 (DID, 2010). Provided that the soil types at a particular area or site are known, this table can be used in determining soil erodibility factor, K to estimating the amount of soil loss or sediment yield at any development area.

| | | |
|---|---|---|
| Soil Name | : | Linau Series. |
| Classification; USDA | : | Typic Sulfaquent. |
| FAO | : | Thionic Fluvisol. |
| Date | : | 21.1.1976. |
| Described by | : | Dr. S. Paramananthan, S.W. Soo, A.K. Rao. |
| Location | : | Simpang Tiga, Kuala Kurau, Perak, Peninsular Malaysia. |
| Landform | : | Flat coastal plain. |
| Elevation | : | 3 – 4 feet a.s.l. |
| Slope | : | 0 – 1%. |
| Landuse | : | Irrigated rice. |
| Parent Material | : | Marine alluvium. |
| Drainage | : | Somewhat very poorly drained. |

**Profile Description**

$A_1$ 0 – 50cm

Dark brown (7.5YR 3/2) wet; clay loam; massive; non sticky; abundant fine roots; clear boundary.

AC 50 – 90cm

Brown (10YR 5/3) wet; clay; massive; slightly sticky; many pieces of decaying wood present; abrupt boundary.

$IIC_G$ 90 – 130cm

Dark greenish grey (5BG 4/1) wet; silt loam. massive; non sticky; many fine roots.

Note : Symbol "G" after Kano (1962).

Figure 5(a) Soil Survey Data Sheet for Malaysia Soil Series (Source: DOA, Malaysia)

**ANALYTICAL DATA OF LINAU SERIES**

| Horizon | Depth (cm) | Particle size analysis % | | | | % | | C/N |
|---|---|---|---|---|---|---|---|---|
| | | clay | silt | fine sand | coarse sand | O.C. | Tot. | |
| $A_1$ | 0–50 | 29.7 | 31.4 | 19.5 | 19.4 | 3.48 | 0.20 | 17 |
| AC | 50–90 | 42.7 | 37.8 | 10.3 | 9.2 | 6.57 | 0.41 | 16 |
| $IIC_G$ | 90–130 | 14.8 | 66.1 | 16.7 | 2.4 | 5.35 | 0.18 | 30 |

| Horizon | pH 1:2.5 | | Exch. A1 meq/100g soil | Water soluble | | E.C. mmhos/cm | Easily sol. P (ppm) |
|---|---|---|---|---|---|---|---|
| | $H_2O$ | KC1 | | $sO_4$% | C1% | | |
| $A_1$ | 4.0 | 3.8 | 5.27 | N.D. | N.D. | 0.1 | 5 |
| AC | 3.0 | 2.6 | 21.11 | 0.73 | 0.02 | 2.1 | 5 |
| $IIC_G$ | 2.8 | 2.2 | 12.77 | 1.73 | 0.04 | 4.2 | 16 |

| Horizon | meq/100g soil | | | | | | Base sat.% | Free iron % |
|---|---|---|---|---|---|---|---|---|
| | CEC | Ca | Mg | Na | K | Total Bases | | |
| $A_1$ | 15.10 | 0.81 | 1.94 | 0.54 | 0.11 | 3.40 | 23 | 0.27 |
| AC | 34.32 | 2.94 | 6.73 | 1.21 | 0.23 | 11.11 | 32 | 1.22 |
| $IIC_G$ | 28.06 | 7.46 | 20.82 | 1.21 | 0.08 | 29.57 | 105 | 2.34 |

Figure 5(b): Analytical Data of Linau Soil Series that shows the percentage of Organic Content (O.C) (Source: DOA, Malaysia)

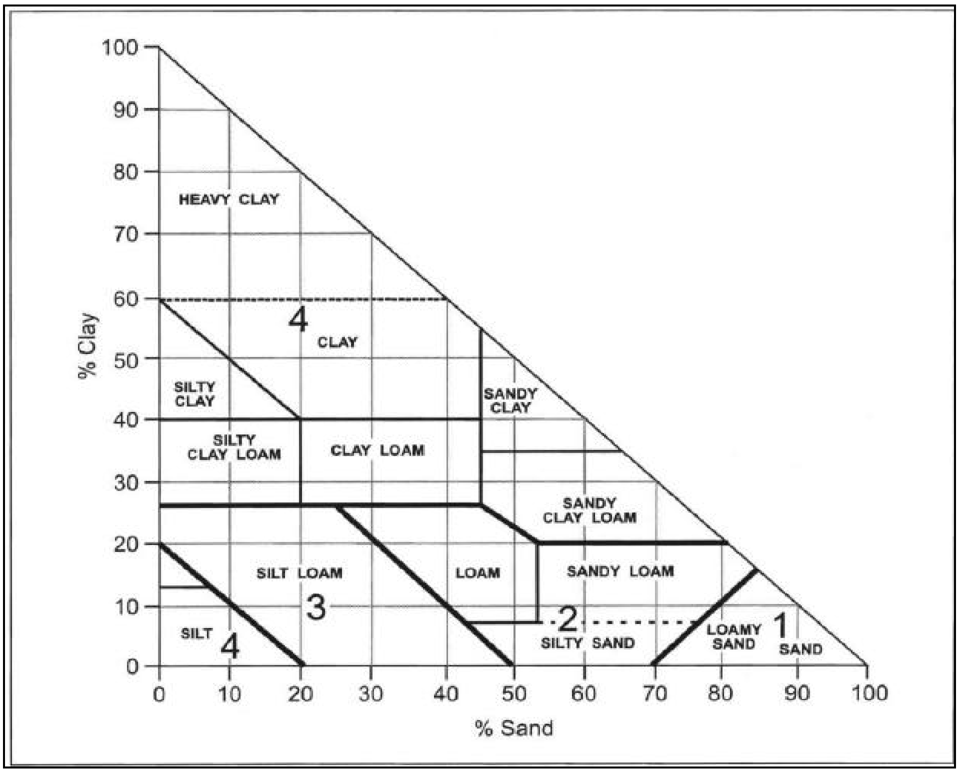


Figure 6 Soil Structure Code based on textural classification (Ontario Centre for Soil Resource Evaluation, 1993)

Table 6 Soil permeability code based on soil texture class

| Soil Texture | Permeability Code[1] | Hydrologic Soil Group[2] |
|---|---|---|
| Heavy clay, Clay | 6 | D |
| Silty clay loam, Sandy clay | 5 | C-D |
| Sandy clay loam, Clay loam | 4 | C |
| Loam, Silt loam | 3 | B |
| Loamy sand, Sandy loam | 2 | A |
| Sand | 1 | A+ |

1 – National Soil Handbook (USDA, 1983), 2 – National Engineering Handbook (USDA, 1972)

Table 7 Soil Erodibility Factor, K For Peninsular Malaysia Soil Series (DID, 2010)

| Bil. | Series | Layers | K Factor (ton/ha)*(ha. hr/MJ.mm) | Texture | HSG |
|---|---|---|---|---|---|
| 1 | Akob | A | 0.053 | clay | D |
| | | B | 0.050 | clay | D |
| | | C | 0.050 | clay | D |
| 2 | Apek | A | 0.045 | clay loam | C |
| | | B | 0.055 | clay loam | C |
| | | C | 0.062 | clay | D |
| 3 | Batu Anam | A | 0.056 | clay | D |
| | | B | 0.057 | clay | D |
| | | C | 0.051 | clay | D |
| 4 | Batu Hitam | A | 0.060 | clay | D |
| | | B | 0.063 | clay | D |
| | | C | 0.063 | clay | D |
| 5 | Batu lapan | A | 0.045 | clay loam | C |
| | | B | 0.049 | clay laom | C |
| | | C | 0.060 | clay | D |
| 6 | Bukit Temiang | A | 0.029 | sandy clay loam | C |
| | | B | 0.038 | sandy clay | C-D |
| | | C | 0.035 | sandy clay loam | C |
| 7 | Beriah | A | 0.053 | clay | D |
| | | B | 0.057 | clay | D |
| | | C | 0.057 | clay | D |
| 8 | Bungor | A | 0.036 | sandy clay loam | C |
| | | B | 0.053 | clay | D |
| | | C | 0.054 | clay | D |

| Bil. | Series | Layers | K Factor (ton/ha)*(ha. hr/MJ.mm) | Texture | HSG |
|---|---|---|---|---|---|
| 9 | Clay Over Organic | A | 0.048 | clay | D |
| | | B | 0.048 | clay | D |
| | | C | 0.048 | clay | D |
| 10 | Chat | A | 0.048 | clay | D |
| | | B | 0.048 | clay | D |
| | | C | 0.048 | clay | D |
| 11 | Chempaka | A | 0.049 | clay loam | C |
| | | B | 0.049 | clay loam | C |
| | | C | 0.045 | clay loam | C |
| 12 | Chengai | A | 0.049 | clay | D |
| | | B | 0.050 | clay | D |
| | | C | 0.050 | clay | D |
| 13 | Chenian | A | 0.056 | clay | D |
| | | B | 0.058 | clay | D |
| | | C | 0.060 | clay | D |
| 14 | Durian | A | 0.053 | clay | D |
| | | B | 0.051 | clay | D |
| | | C | 0.051 | clay | D |
| 15 | Guar | A | 0.052 | clay | D |
| | | B | 0.052 | clay | D |
| | | C | 0.053 | clay | D |
| 16 | Halu | A | 0.051 | sandy clay loam | C |
| | | B | 0.058 | sandy clay loam | C |
| | | C | 0.051 | sandy clay loam | C |

Table 8 Range of Soil Erodibility for Soil Type of Peninsular Malaysia Soil Series

| Soil Type | K Factor (ton.ha)(ha.hr/MJ.mm) |
|---|---|
| Clay | 0.042 – 0.065 |
| Clay loam | 0.030 – 0.047 |
| Sandy Clay | 0.031 – 0.043 |
| Sandy Clay Loam | 0.028 – 0.059 |
| Sandy Loam | 0.004 – 0.036 |
| Silt Loam | 0.014 – 0.027 |
| Silty clay loam | 0.032 |

From the results obtained for 74 soil series for Peninsular Malaysia, the range of soil erodibility factor, K for each soil type are as in Table 8 above.

Out of 74 soil series for Peninsular Malaysia, it is found that 56 percent of the soil series, such as Akob, Batu Anam, Chengai and etc, were high with clay content and having the erodibility factor ranging from 0.042 (ton.ha)(ha.hr/MJ.mm) to 0.065(ton.ha)(ha.hr/MJ.mm) which is most susceptible to erosion. Soil series such as Muchong, Renggam, Holyrood and etc which is sandy clay soil having the erodibility factor from 0.031(ton.ha)(ha.hr/MJ.mm) to 0.043(ton.ha)(ha.hr/MJ.mm) were moderately eroded. Sandy loam soil type such as Lunas and Marang are less erodible since the erodibility factor for the soils ranging from 0.004(ton.ha)(ha.hr/MJ.mm) to 0.036 (ton.ha)(ha.hr/MJ.mm. Rudua soil series with high silt content having erodibility factor ranging from 0.014(ton.ha)(ha.hr/MJ.mm) to 0.027 (ton.ha)(ha.hr/MJ.mm).

From the assessments carry out for these 74 soil series of Peninsular Malaysia, it is found that the Rusila series with high sand content gives poor estimation on erodibility factor by using Tew equation or nomograph. For this, further study is needed in determining the soil erodibility factor for soil series that having high content of sand and silt.

**Summary**

From the assessments of soil erodibility factor carry out for 74 soil series of Peninsular Malaysia using Tew equation, it is found that the erodibility factor ranging from silt loam to clay soil were 0.014 (ton.ha)(ha.hr/MJ.mm) to 0.065(ton.ha)(ha.hr/MJ.mm) respectively.

A few different method or parameter in determining soil erodibility factor in this assessment were use to compare with Tew (1999) study which are (1) soil structure code using Soil Textural Pyramid by USGS which Tew just classification using physical observation on the soil materials, (2) soil permeability code using USDA National Soil Handbook, 1983 which Tew using permeability test result for 26 soil series of. The current study also carry out the erodibility factor for 3 main horizon namely layer A (0-0.5m deep), layer B (0.51 – 1.00m deep) and layer C (1.00m – 1.50m deep) of each soil series in which it can be use as references in determining soil loss of at any developing area either for construction or agriculture.

With this new assessment on soil erodibility factor, K for 74 soil series of Peninsular Malaysia, a better result can be obtained in estimating soil loss or sediment yield at any proposed development area either for construction of agriculture purpose. Tew equation (1999) gives better result to compare with Weischmeier equation (1978) in USLE for Malaysia soil series condition.

**Acknowledgements**

I would like to thanks Department of Irrigation and Drainage (DID) Malaysia and Department of Agriculture (DOA) Malaysia in giving the opportunity in carry out the research and study.

**References**

1. Hashim, G.M., Wan Abdullah, W.Y. (2005). Prediction of Soil and Nutrient Losses In A Highland Cathment, Malaysia Agriculture Research And Development Institute (MARDI), Water, Air and Soil Pollution: Focus 5, pg 103-113
2. Wischmeier, W.H., Johnson, C.B., Cross, B.V., (1971). A Soil erodibility nomograph for farmland and constructions. Journal of Soil and Water Conservation,26: pg 189-193.
3. Wischmeier, W.H., Smith, D.D., (1978). Predicting Rainfall Erosion Losses. A Guide to Conservation Planning, USDA-SEA,U.S., Governmental Printing Office, Washington
4. Morgan,R.C.P. (1996). Soil Erosion and Conservation, 2nd Edition, Longman Publisher.
5. Department of Agriculture. (1995). Guideline for Soil Series of Peninsular Malaysia
6. Tew, K.H., (1999). Production of Malaysian Soil Erodibility Nomograph in Relation to Soil Erosion Issues. VT Soil Erosion Research & Consultancy., 27, Jalan SS 14/2D, 47500 Subang Jaya, Selangor Darul Ehsan, Malaysia
7. Department Of Agriculture (DOA).(2010). Soil Survey Data for Peninsular Malaysia.
8. Department of Irrigation and Drainage (DID). (2010). Guideline For Erosion And Sediment Control In Malaysia.
9. United State Department of Agriculture (USDA).(1983). National Soil Handbook.
10. United State Department of Agriculture (USDA).(1972). National Engineering Handbook.
11. United State Geology and Soils (USGS) Ontario Centre for Soil Resource Evaluation, 1993)